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FRONTAL MOVEMENTS CONTRARY TO INDICATED GRADIENT FLOW PRODUCED BY MINOR WAVES

By A. K. SHOWALTER
[Weather Bureau, Washington, May 1938]

During the past 2 years considerable improvement has been effected in the technique of the analysis of synoptic weather maps. There has been a definite trend toward elimination of fronts which show displacements inconsistent with the indicated gradient flow; but historical sequence has been and always must be the basic criterion for the identification of a front. A problem often encountered by the synoptic analyst is the paradox of a surface front for which good historical evidence exists, but which is moving directly against the gradient flow indicated by sea-level isobars.

The basic requirement for a surface front is that an isentropic surface (1) intersect the ground at an appreciable angle. Any air of greater entropy moving along the surface of the earth must therefore rise when it comes in contact with this frontal or isentropic surface. Displacement of such a frontal surface is produced by the component of winds normal to the front, because air cannot blow through an isentropic surface, except by mechanical turbulence over rough terrain. The geostrophic wind velocity component normal to a frontal surface is therefore ordinarily a good indication of the rate of movement of a front.

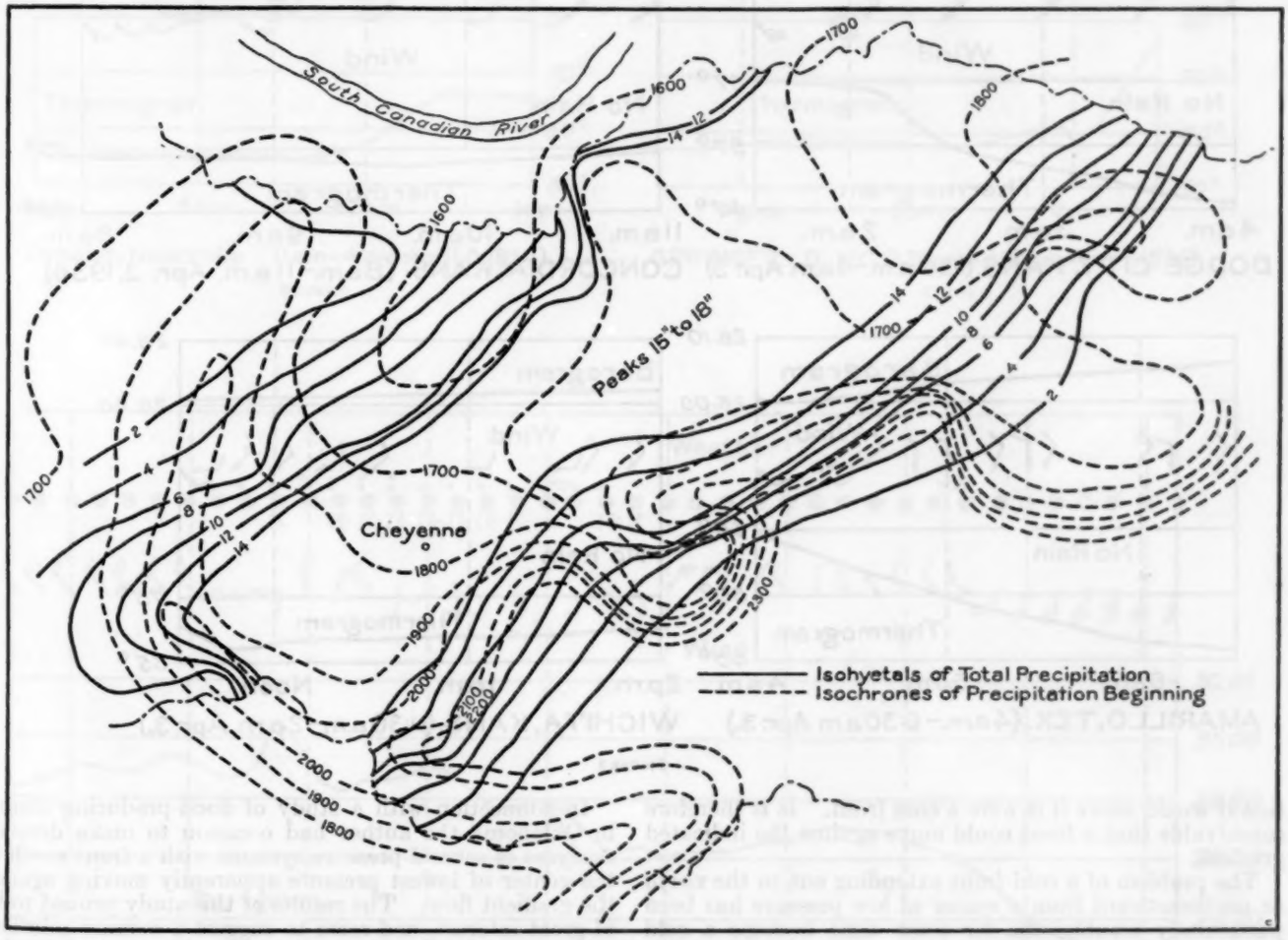


FIGURE 1.—Isohyetals in the vicinity of Cheyenne, Okla., with the isochrones of the beginning of precipitation for the evening of April 3, 1934. Precipitation is given in inches and time is given according to the 24-hour scale.

There is another important force affecting the movement of fronts which is too often neglected. That is the isallobaric component. Brunt and Douglas (2), and Petterssen (3) have stressed the importance of the isallobaric component in a deepening depression. This component is usually directed towards the center of low pressure and may be in direct opposition to the gradient flow, especially near a warm front. Displacement of a warm front is directly proportional to the component of the cold air away from the front. If the isallobaric component in the cold air is opposite to, and equals or exceeds the component of, the gradient velocity the warm front may be held stationary or move backwards; that is, in the direction it would move if it were a cold front. It is therefore conceivable that a front could move against the indicated gradient.

The problem of a cold front extending out to the north or northeastward from a center of low pressure has been particularly troublesome for some time because a cold front in such a position defies the laws of gradient flow. If any front existed in such a position, gradient winds would carry it counterclockwise around the LOW. However, there often appeared to be good historical evidence for frontal activity in such a position, and further evidence for the front remaining in the same relative position while the low pressure center and the trough to the northeastward moved along to the south or southeast. The pressure tendencies in such cases are usually masked by the effects of movement of the pressure system, and appear identical with those of an ordinary front. An easy solution of the problem therefore seems to be to introduce an upper air front in such a region, which is perfectly logical since there is good evidence that upper fronts not only can but do exist north of the surface position of the center of an occluded depression (4). However, an upper front not only demands a previous occlusion but also a very sudden increase in the slope of isentropic surfaces aloft. Such an increased slope should be accompanied by definite changes in wind direction and velocity at the level of steepest slope or in other words at the level of the front. These criteria for upper fronts are apparently all fulfilled on some occasions, but some or all of them are not fulfilled in other cases of apparent frontal activity.

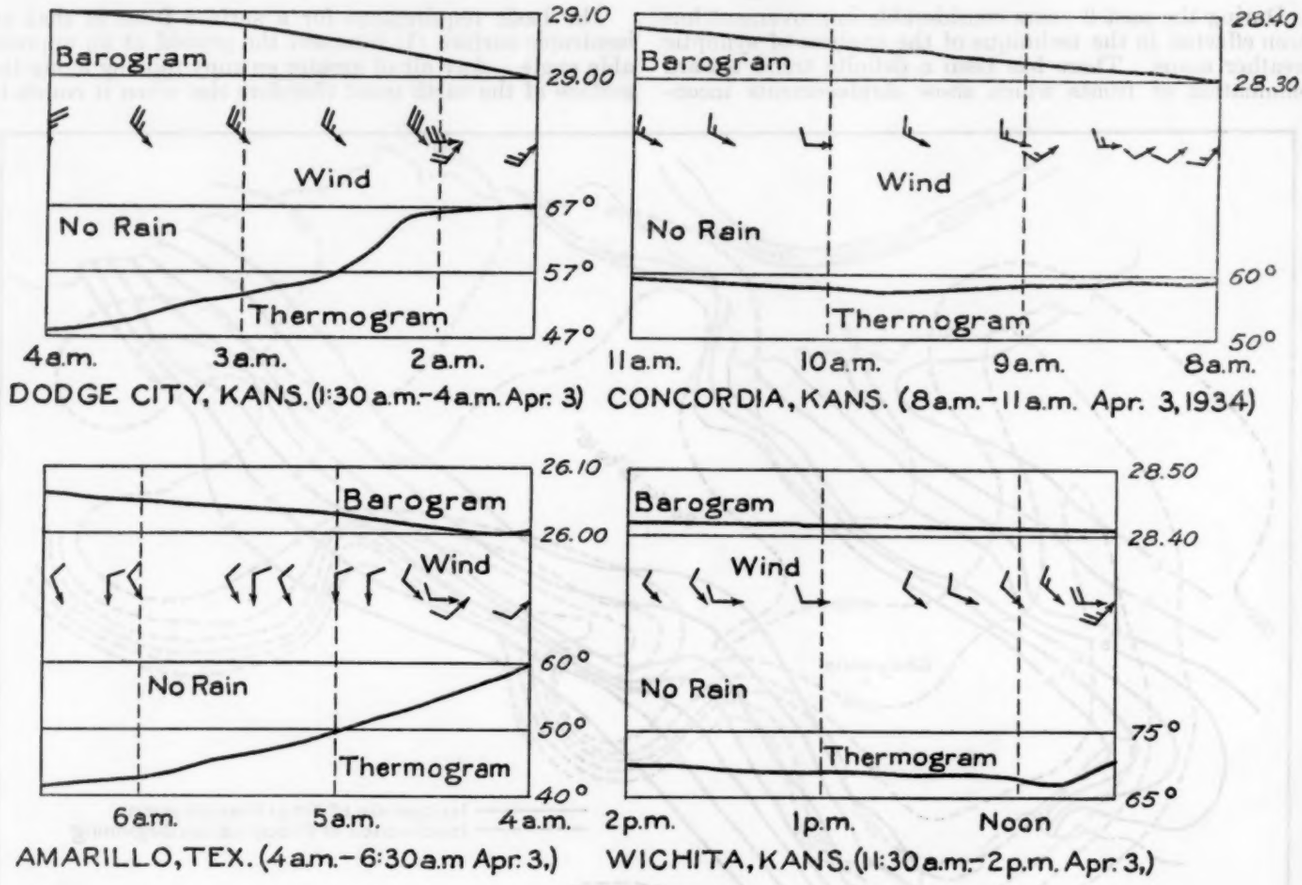
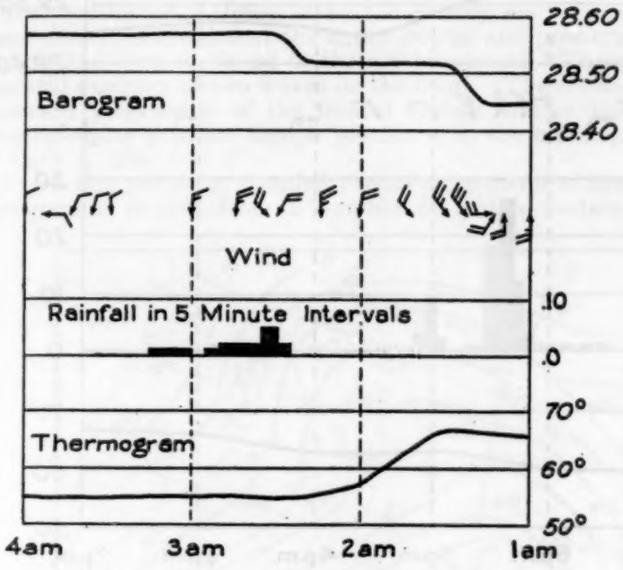


FIGURE 2.

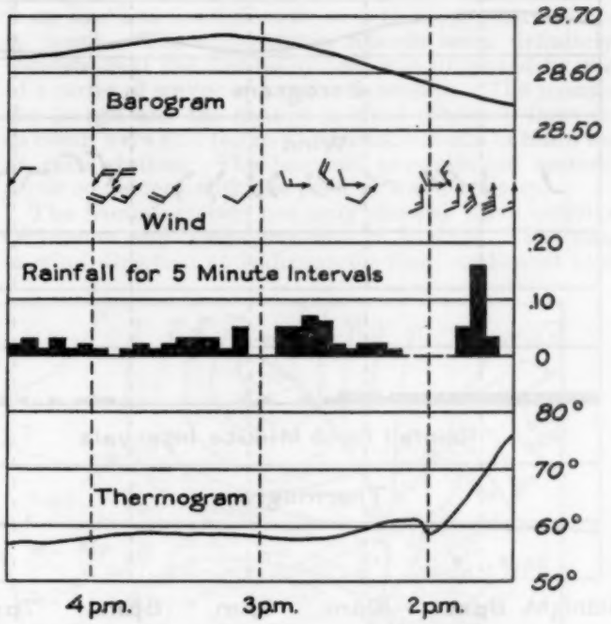
In connection with a study of flood-producing storms in Oklahoma the author had occasion to make detailed analyses of several pressure systems with a front north of the center of lowest pressure apparently moving against the gradient flow. The results of this study proved to be of great interest, and seem to suggest a definite solution. The storm of April 1934 which produced very heavy rains in western Oklahoma is a good example of the general type, and a discussion of this storm brings out the significant features:

On the morning of April 2, 1934, and oval-shaped low pressure system was central over northern Colorado. To the north of this system was a mass of polar Pacific air, and south of the center a modified form of polar Pacific air. The surface data seemed to indicate a warm front in central Nebraska and a cold front running from northwestern Nebraska to southwestern Utah. There was



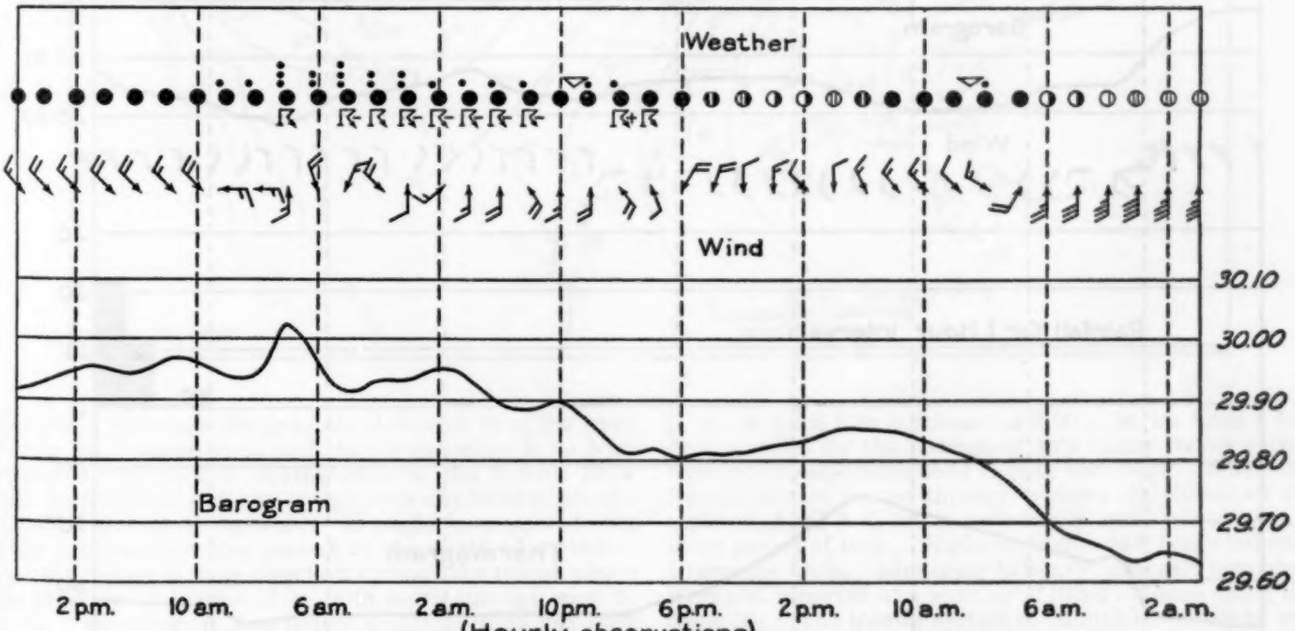
Omaha, Nebraska (1am–4am April 3, 1934)

FIGURE 3.



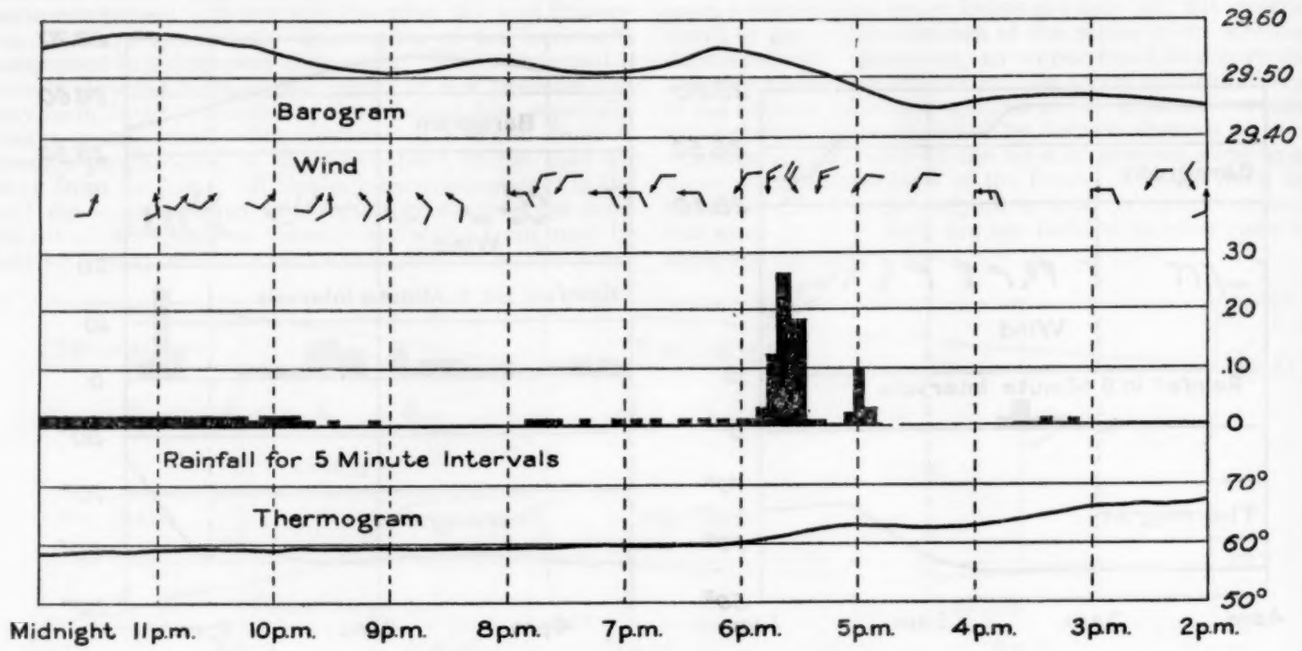
SPRINGFIELD, MO. (1.30p.m.–4.30p.m. Apr. 4, 1934)

FIGURE 4.



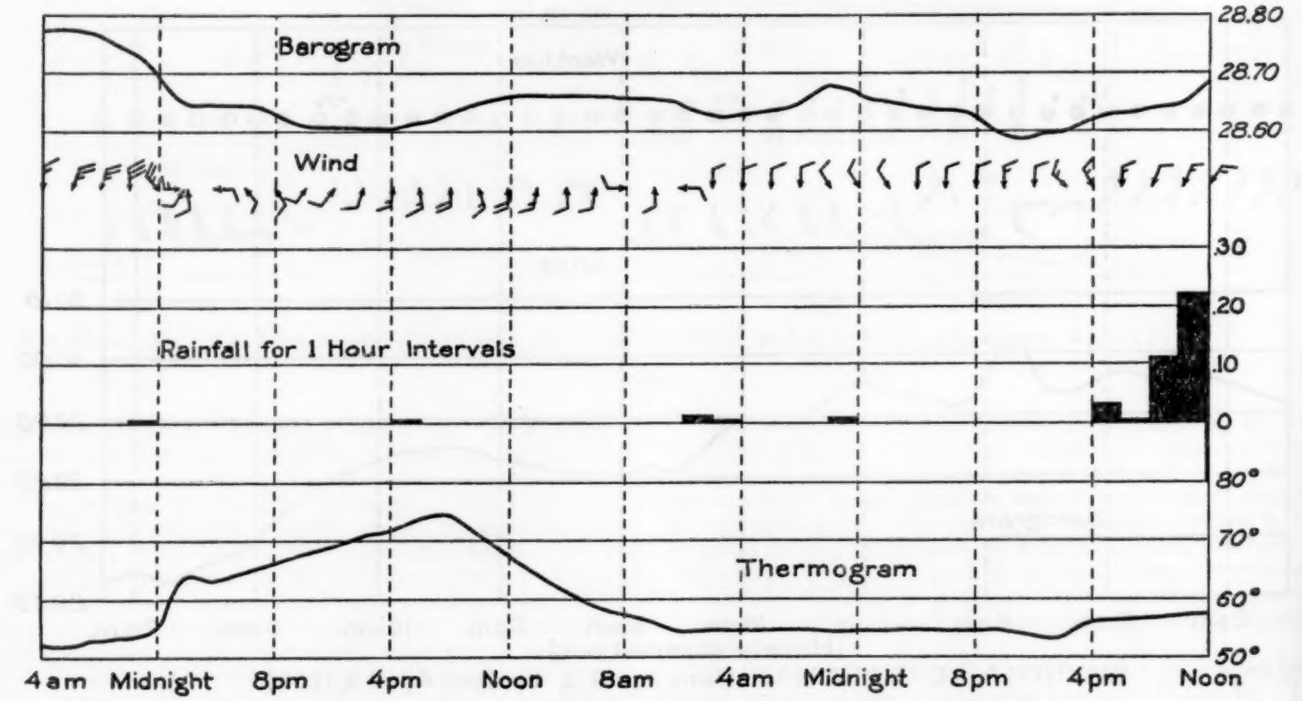
WAYNOKA, OKLAHOMA. (1a.m. April 3, to 4p.m. April 4, 1934)

FIGURE 5.



FORT SMITH, ARK. (2p.m.–12p.m. April 4, 1934)

FIGURE 6.



OKLAHOMA CITY, OKLAHOMA (Noon April 4 to 4am April 6, 1934)

FIGURE 7.

some evidence for a secondary wave in northwestern Colorado. Pressure was rising quite rapidly north of the center, and falling moderately to the south and southeastward. The gradient flow indicated in Nebraska suggested that the warm front in this region should have moved northward. However, on the evening map of the same date it is noted that the entire frontal and pressure system had been displaced to the southeastward. There was still evidence of two waves on the front. The southeastward progression of the frontal system and of the accompanying pressure trough continued to the morning of April 3, 1934.

From this point on, detailed checks were made of the autographic records from a number of middle-western stations. Although the gradient indicated that the front should be a warm front and should therefore have been displaced westward or northwestward, the records show that the front and pressure trough were displaced gradually eastward and southeastward. It might be expected that when a pressure center passed to the south of a station that the change in wind direction through the trough above the pressure center would be from south through east to north. However, it was found that the front not only moved against the indicated gradient flow, but also showed definite frontal characteristics as it passed each station. Graphical reproductions of the autographic records for a number of stations during the passage of the trough and subsequent waves are shown in the accompanying figures.

The chart of the hourly observations for Waynoka, Oklahoma, also shows the effects of the frontal and wave passages. In all cases it was found that the wind shifted from south to southwest to west to northwest and finally to north. The autographic records seem definitely to indicate that the frontal system was displaced by means of a series of waves of varying intensity. The passage of the trough and the change in wind direction from south to north were effected by the passage of one or more waves at each station. The heaviest precipitation seemed to occur coincident with the peak of wave activity.

The frontal system not only showed wave activity in Oklahoma and Texas but also in Indiana. The change in wind direction at Indianapolis from southwest at 8:00 p. m. on April 3 to northeast at 8:00 p. m. on April 4 was accompanied by the passage of two minor waves with a definite cyclonic wind shift in both instances. When this frontal system passed through western Oklahoma on the night of April 3–4, 1934, very heavy rains occurred in a short period of time. Eighteen inches in 6 hours fell near Cheyenne, Okla. Moderate to heavy rains and tornadoes were also reported at a number of other stations along the front (5). The frontal system continued its eastward and southward displacement until the morning of April 5, 1934. Its passage to the eastward was identified by means of autographic records for stations in the Mississippi Valley. All these stations seemed to further indicate the displacement by means of a series of minor waves. The records

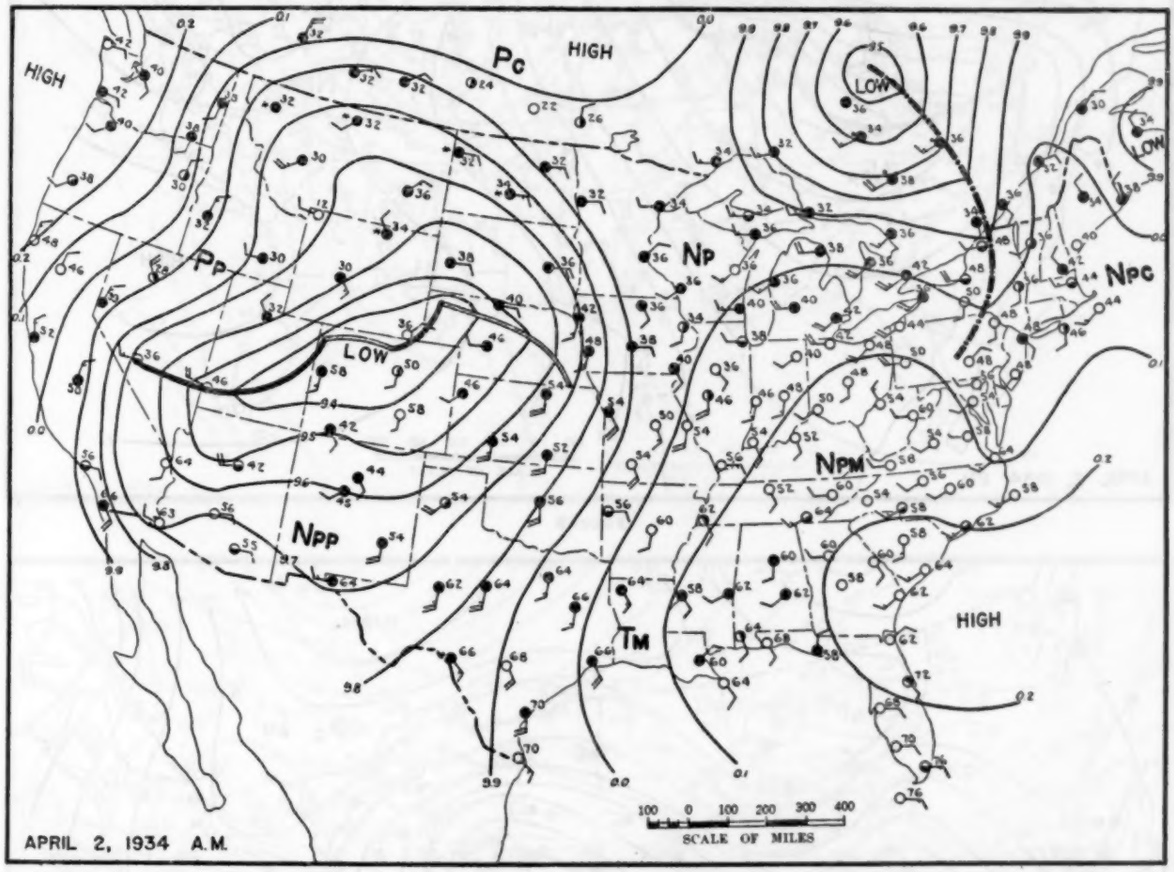


FIGURE 8.

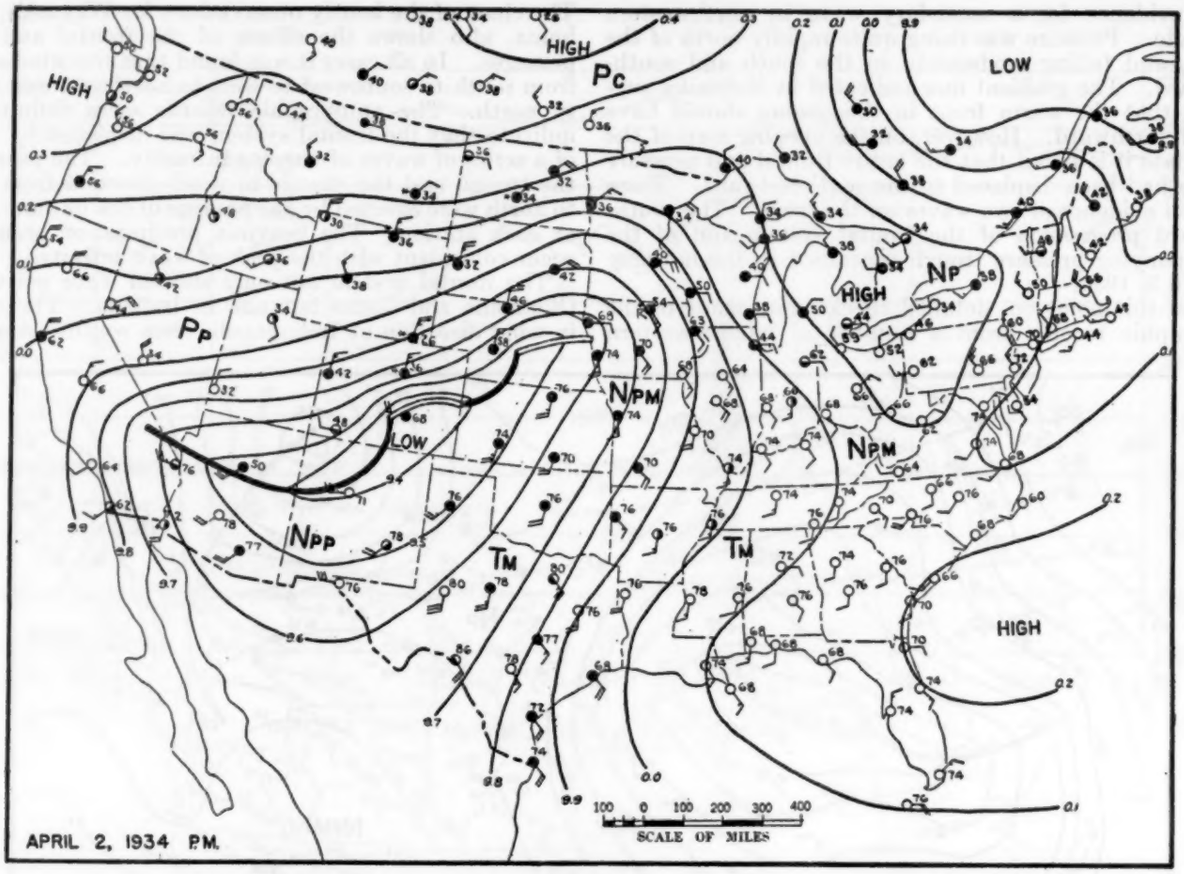


FIGURE 9.

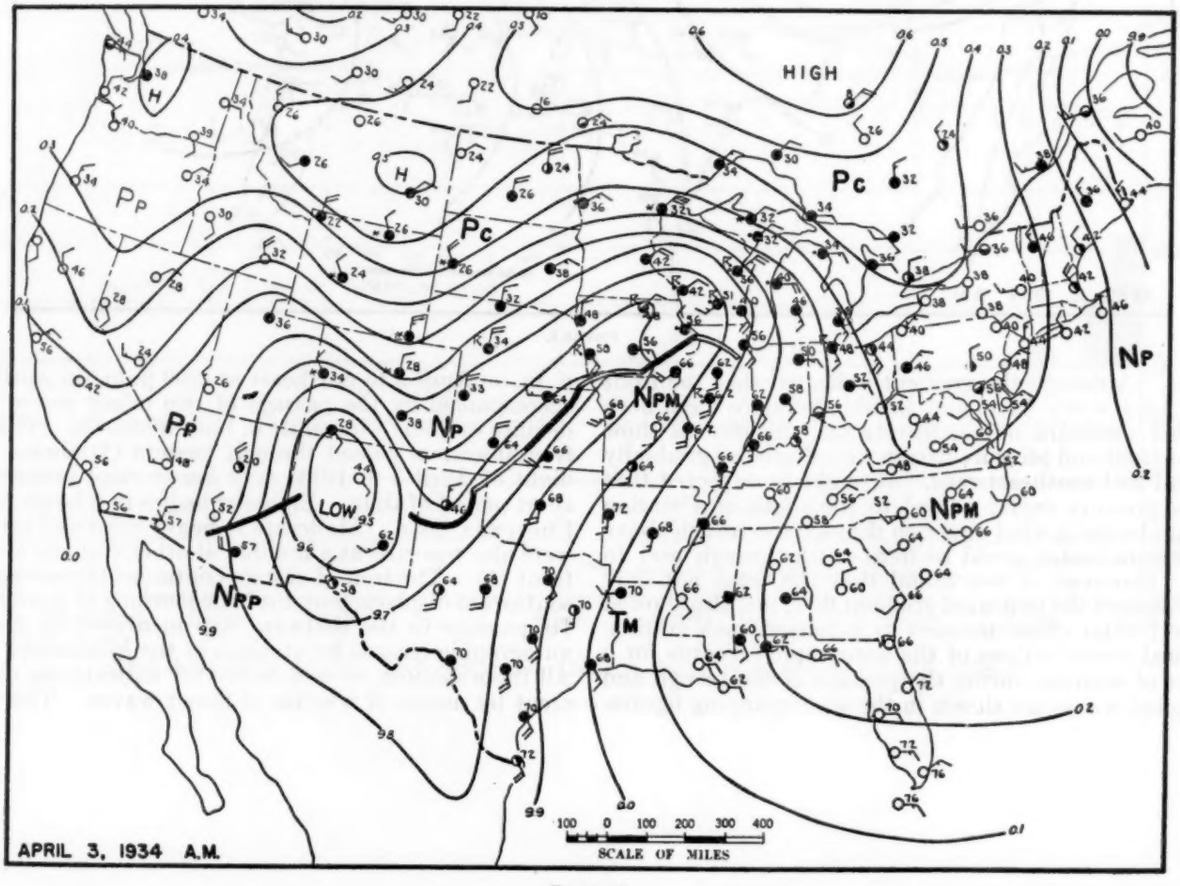


FIGURE 10.

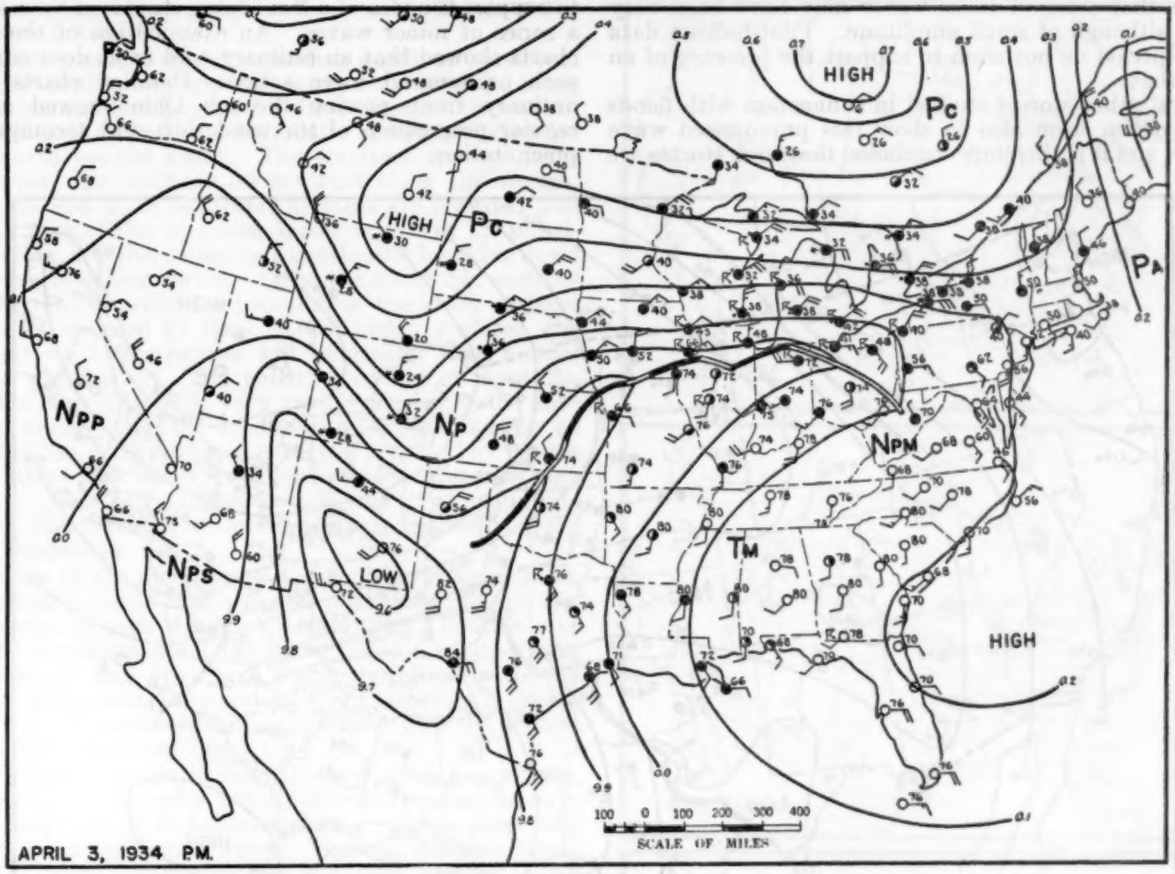


FIGURE 11.

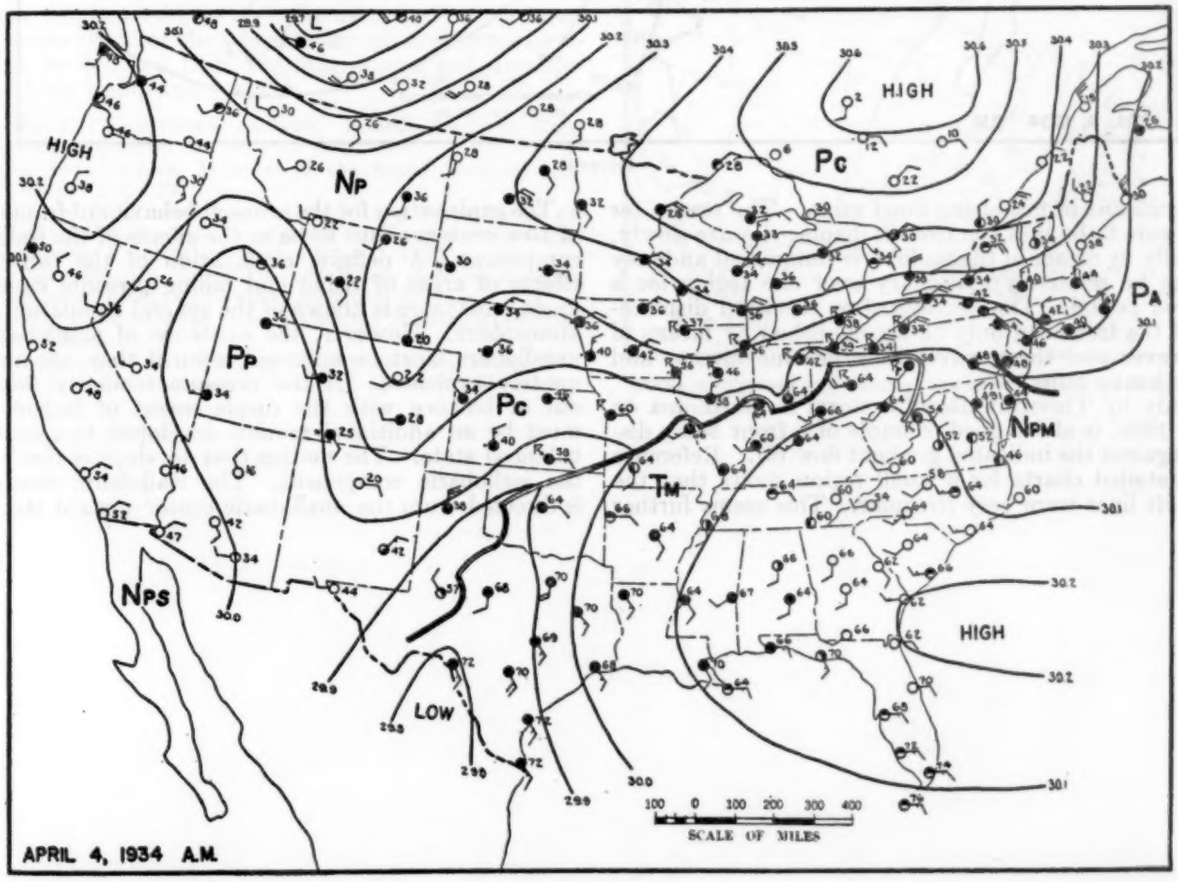


FIGURE 12.

indicate that some of these waves may have been very intense although of small amplitude. Pilot-balloon data for this period do not seem to support the presence of an upper front.

Several other storms studied in connection with floods in this region seem also to show this pronounced wave activity, and it is therefore concluded that such storms are to support the idea of a front being displaced by means of a series of minor waves. An examination of the file of charts showed that an ordinary cold front does not have such pronounced wave action. Detailed charts of an ordinary front passing through Ohio showed a very regular progression of the wind shift and accompanying precipitation.

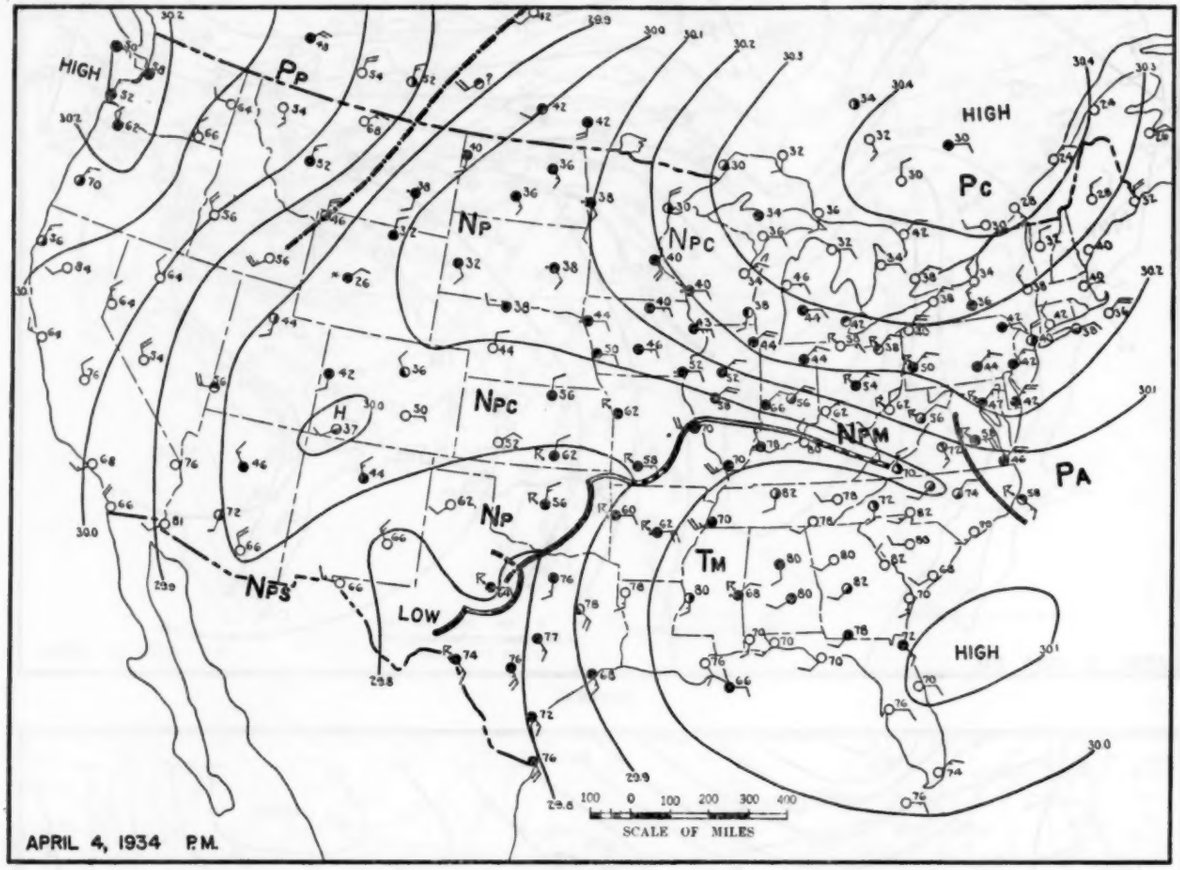


FIGURE 13.

very significant in producing flood rains. The reason for this appears to be that the front is displaced quite slowly, principally by means of the isallobaric component and may therefore be relatively stationary over one region for a prolonged period. The southward or eastward displacement of the front can only be accomplished by means of small waves and these waves may become intense and produce heavy rains.

A study by Thornthwaite of a storm in Oklahoma on May 1, 1936, is also a good example of a front being displaced against the indicated gradient flow **(6)**. Reference to his detailed charts for a small region shows that the wind shift lines were very irregular. This seems further

The explanation for the unusual behavior of fronts north of LOW centers seems to be in the effects of the isallobaric component. A definite explanation of the causes and effects of areas of rising and falling pressure cannot be made until more is known of the general circulation of the atmosphere. However, the existence of anallobars and katallobars must be accepted, even if they are not adequately explained. If the pressure tendency fields are out of balance with the displacement of isobars there must be an additional motion developed to maintain a balanced state. The motion that develops is that due to the isallobaric component. The isallobaric component is directed from the anallobaric center toward the katal-

lobaric center and its magnitude is proportional to the isallobaric gradient.

In a low-pressure trough extending northeastward from a cyclonic center, two opposing forces may develop. First, the component due to gradient flow, directed from south to north, and second, the isallobaric component directed from north toward south. The resultant motion tends to sharpen the temperature contrast along the trough, and more and more isentropic surfaces are crowded into a small area. The opposing forces represent an unbalanced state, and there must be a continuous breaking down by means of minor waves. Since the isentropic surfaces have become crowded, and motion in the lower surfaces is directly opposed to those in the higher surfaces, the resultant vertical velocities will be greater than normal for the warmer air. The potential energy of mass distribution may therefore very rapidly be converted into kinetic energy and the resultant wave action may be quite intense. If additional energy is provided by release of the latent heat of condensation severe local storms may develop. Such storms cannot attain very great magnitude because their continued development is opposed by the major depression.

Because of the direction of the isallobaric component, and further because of the greater density of the cold air, the passage of each minor wave results in a southerly or easterly displacement of the mean position of the front. The front at any point will recede but little with the passage of the next wave and the front therefore is gradually displaced eastward and southward directly against the indicated gradient flow.

This type of storm is considered of great importance, not only for flood studies but also for short-period airways forecasting; and it is believed that a rigid analysis will identify these very small waves. Such an analysis should not only prove interesting but also very helpful to the forecaster. The immediate indications of the movements of minor waves would be their behavior in the last hour. The general trend of the pressure trough and frontal system can be deduced from the magnitudes and displacements of the isallobaric systems.

(1) Rossby, C. G., Isentropic Analysis. Bulletin American Meteorological Society, vol. 18, June–July 1937.
(2) Brunt and Douglas, Memoirs of the Royal Meteorological Society. 3 No. 22.
(3) Petterssen, S., Kinematical and Dynamical Properties of the Field of Pressure with Application to Weather Forecasting. Geofysiske Publikasjoner, vol. 10, No. 2, 1933.
(4) Lichtblau, Stephen, Upper-Air Cold Fronts in North America. MONTHLY WEATHER REVIEW, December 1936.
(5) Monthly Climatological Data, Oklahoma Section, April 1934, vol. XLIII, No. 4.
(6) Thornthwaite, C. W., The Life History of Rainstorms. Geographical Review, vol. XXVII, No 1, January 1937.

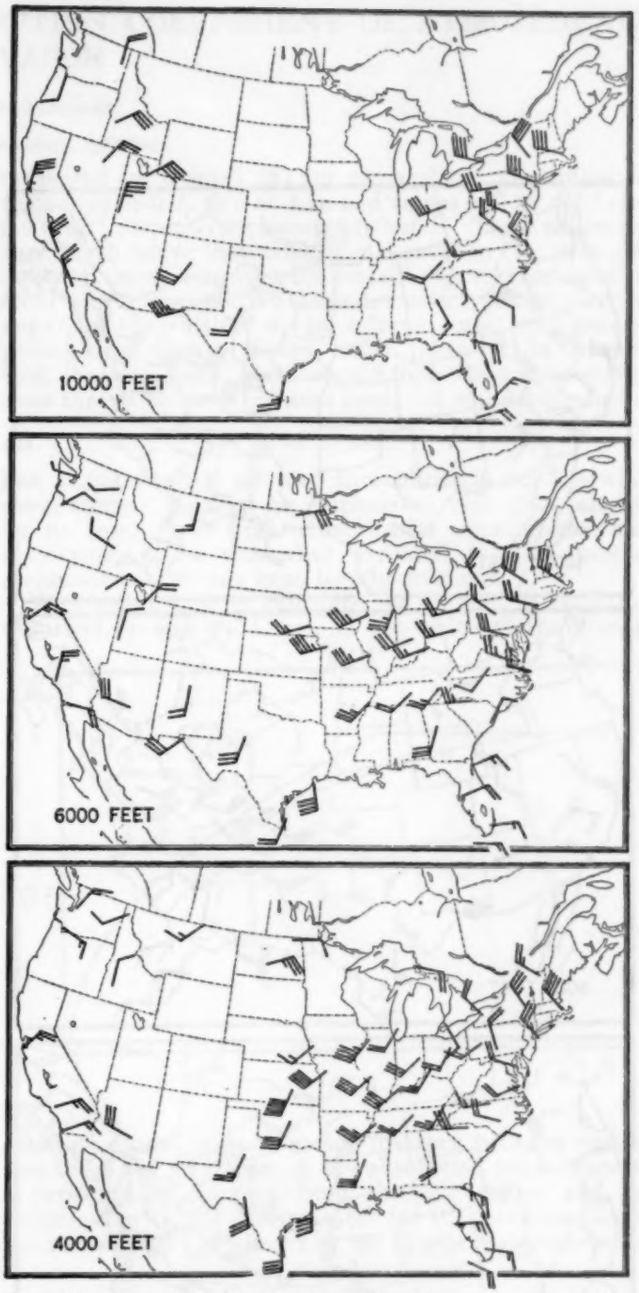


FIGURE 14.—Upper-air wind velocities at the morning observation on April 3, 1934.

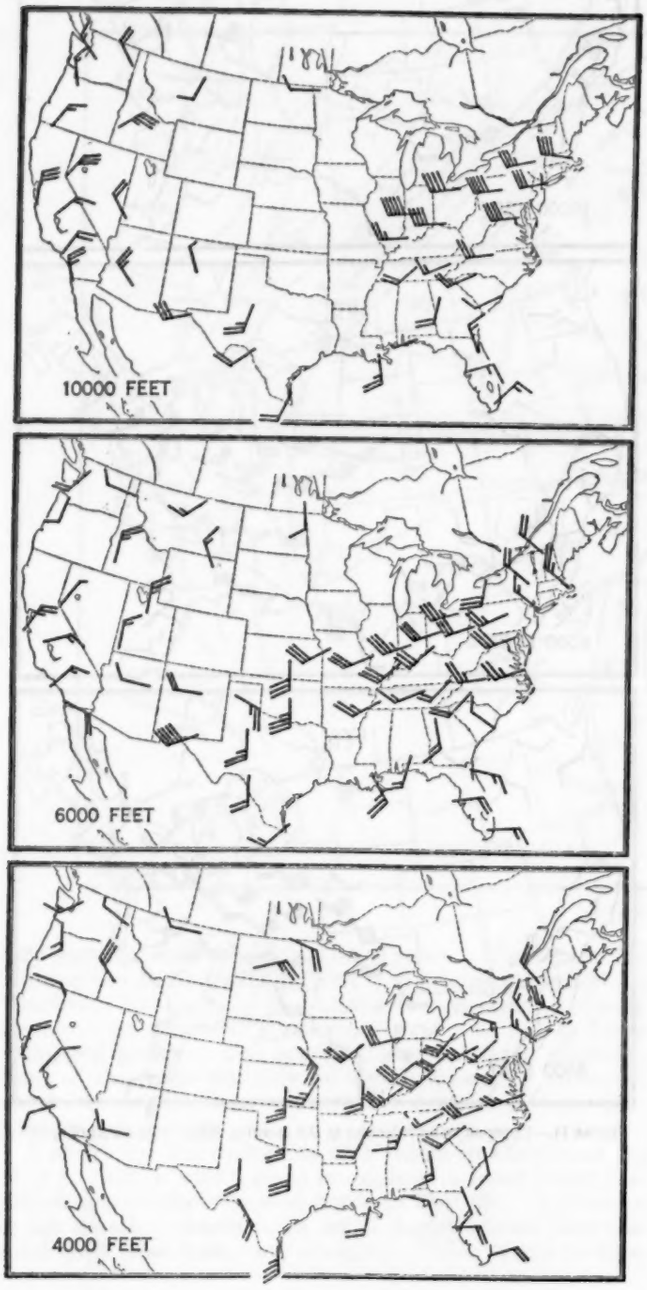


FIGURE 15.—Upper-air wind velocities at the evening observation on April 3, 1934.

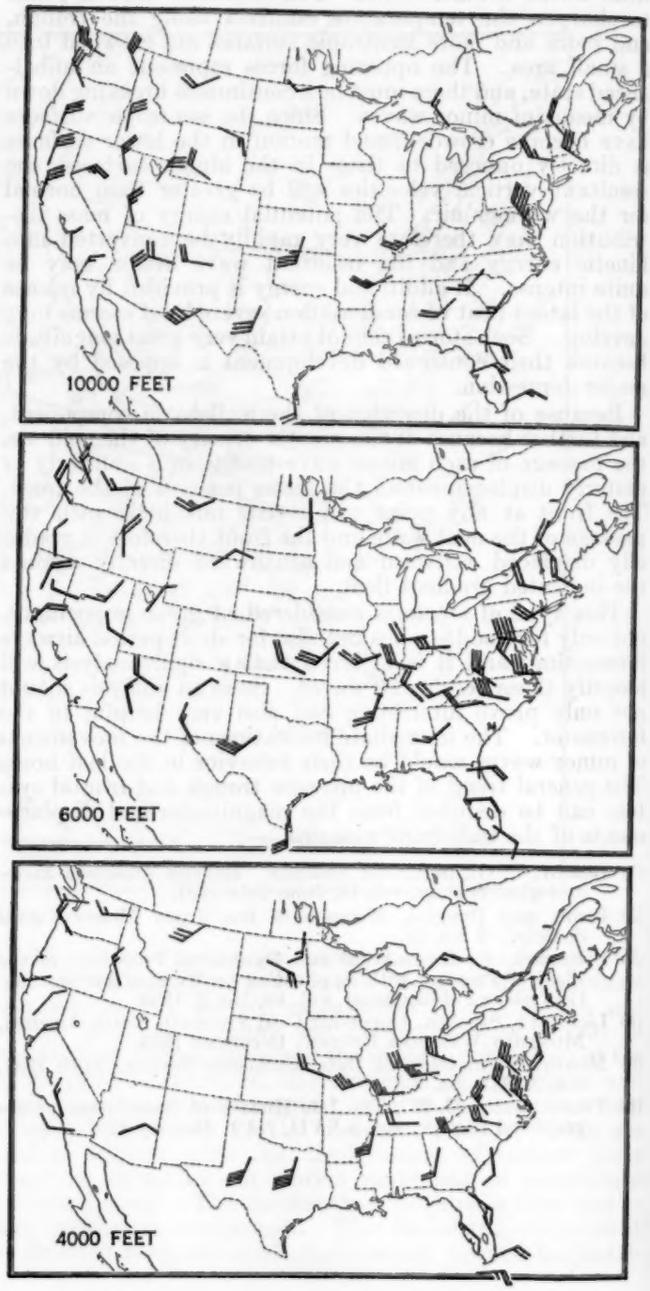


FIGURE 16.—Upper-air wind velocities at the morning observation on April 4, 1934.

NEW VALUES FOR THE INFRARED ABSORPTION COEFFICIENT OF ATMOSPHERIC WATER VAPOR

By WALTER M. ELSASSER

[California Institute of Technology, April 1938]

Some time ago the writer examined those features of atmospheric radiation which ensue from the fact that the water vapor spectrum is a line spectrum and not a continuous spectrum (1). At that time it was not possible to give a quantitative redetermination of the absorption, since our spectroscopic knowledge of the far infrared region was not sufficiently advanced. In the meantime, the work of Randall, Dennison, Ginsburg, and Weber (2) has furnished us with a complete analysis of the far infrared line spectrum of water vapor covering the whole spectrum beyond a wave length of 18μ. These authors have been able for the first time to resolve the spectrum completely into its individual lines; the wave lengths of the lines have been measured and their intensities, which are difficult to measure directly, have been determined by calculations based upon the quantum theory of the water molecule. On the basis of these important results, in combination with the rest of our knowledge of the water spectrum, it has now become possible to obtain improved numerical values for the absorption coefficient of atmospheric water vapor and its dependence upon pressure and temperature. Our calculations apply not only to the part of the spectrum covered in reference (2), but to the whole range of the infrared spectrum where the thermal radiation of the atmosphere and ground is appreciable. We might notice here that the necessity for taking the line structure of the water spectrum into account, in dealing with problems of atmospheric radiation, has been pointed out several years ago by F. Albrecht (3).

1. LINE ABSORPTION

The spectrum beyond 20μ is covered by numerous and narrow spectral lines which are tabulated in (2). The form and properties of the spectral lines have been discussed in (1). If the total intensity of a spectral line is designated by i_0, then the intensity distribution of the line (i. e. the dependence of the absorption coefficient on frequency) is given by the formula

$$i(\nu)=\frac{i_0}{\pi}\cdot\frac{\alpha}{(\nu-\nu_0)^2+\alpha^2}. \tag{1}$$

Here ν_0 is the frequency of the line center and α is a constant which has the dimension of a frequency. In spectroscopic practice it is customary to use reciprocal wave lengths (cm^{-1}) as a measure of the frequency scale; in order to obtain true frequencies (sec^{-1}), it is only necessary to multiply them by the velocity of light, $c=3.10^{10}$ cm sec^{-1}. We shall adopt this scale throughout.

The constant α is a measure of the width of the line; it can be assumed to be about the same for all lines in the spectrum; however, as explained in (1), it is proportional to the air pressure and inversely proportional to the square root of absolute temperature:

$$\alpha=\alpha_0\frac{p}{p_0}\frac{\sqrt{T_0}}{\sqrt{T}}, \tag{2}$$

where p_0 and T_0 are standard pressure and temperature. In (1), an estimate of the magnitude of α_0 has been attempted. In the meantime this quantity has been measured by Cornell (4) for atmospheric absorption in the bands at 0.9μ and at 1.1μ and values of 0.29 cm^{-1} and 0.20 cm^{-1}, respectively, have been found. These values are very much larger than the one estimated in (1); they are, however, in agreement with certain other experiences of band spectroscopy. We have no direct information as yet about the width of the far infrared lines; from general principles of atomic theory, it can, however, be inferred that the line width there should not differ appreciably irom that of the near infrared lines. A standard value of

$$\alpha_0=0.25\ cm^{-1} \tag{3}$$

has, therefore, been adopted throughout in our following calculations. It must be emphasized that this value is by no means free from experimental uncertainties and may possibly be somewhat modified if more precise measurements of this type become available.

We proceed now to calculate the amount of radiation absorbed by spectral lines. If the width of the lines is

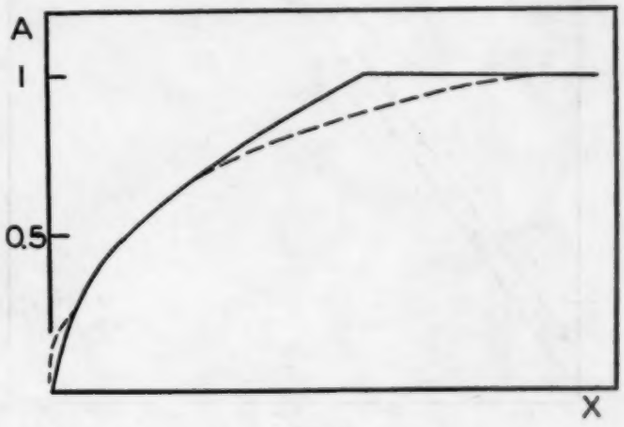


FIGURE 1.

small compared to the average distance between successive lines, the main part of the absorption takes place at a considerable distance from the line center and, as explained in (1), the formula (1) for the intensity distribution can then be replaced by the approximate expression

$$i(\nu)=\frac{i_0\alpha}{\pi(\nu-\nu_0)^2}; \tag{4}$$

$i(\nu)$ means physically the amount of radiation absorbed in an infinitesimal layer of water vapor. In a layer of finite optical thickness x, say, the radiation will be weakened according to the law $I=I_0e^{-ix}$. We define now the *fractional absorption* in a layer of finite thickness as

$$A=\frac{I_0-I}{I_0},$$

and more generally as the fraction of the primary radiation absorbed in the layer. We can now readily compute the fractional absorption due to the presence of a single spectral line. Consider a spectral interval $\Delta\nu$ so large

that the absorption due to the line is only appreciable inside it and is negligible outside it; on the other hand, it might be small enough that inside it the light intensity can be considered a constant independent of frequency. We define A, then, as

$$A=\frac{\int(I_0-I)d\nu}{\int I_0 d\nu}=\frac{1}{\Delta\nu}\int(1-e^{-i(\nu)x})d\nu.$$

The limits of the interval $\Delta\nu$ are also the limits of the integration; but on account of the assumptions made, we can, without appreciable error, replace these limits by $-\infty$ and $+\infty$. We have, then, by (4):

$$(5)\qquad A=\frac{1}{\Delta\nu}\int_{-\infty}^{+\infty}\left(1-e^{-\frac{i_0\alpha x}{\pi(\nu-\nu_0)^2}}\right)d\nu=\frac{2\sqrt{i_0\alpha x}}{\Delta\nu}.$$

If the interval contains several spectral lines which are so far apart from one another that each can be assumed to

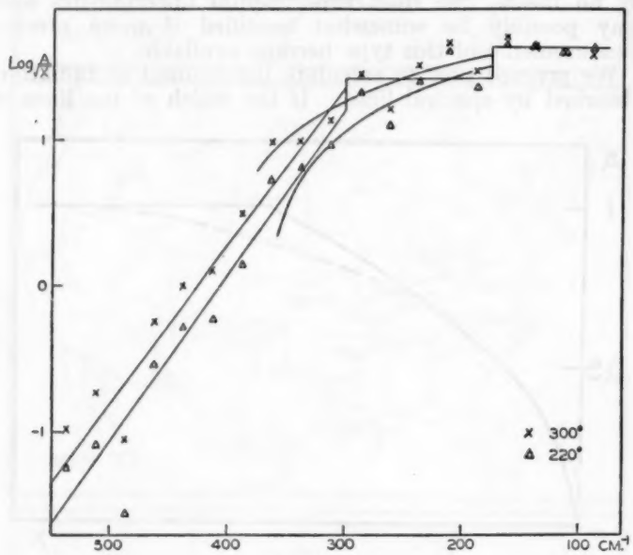


FIGURE 2.

absorb independently from the others, we will, for the fractional absorption, have a *sum* of terms having all the form of the right-hand side of (5). Introducing the expression (2) for α, we have finally

$$(6)\qquad A=\frac{2\sqrt{\alpha_0}}{\Delta\nu}\sum\sqrt{i_0}\sqrt{\frac{p}{p_0}}\sqrt{\frac{T_0}{T}}\sqrt{x},$$

where the summation extends over all lines in the interval $\Delta\nu$. The absorption is, therefore, proportional to the square root of the optical mass x (we shall measure x in cm. of precipitable water); it is proportional to the square root of the air pressure and inversely proportional to the fourth root of the absolute temperature. The latter statement is, of course, only true *if the pressure and temperature can be assumed constant throughout the layer;* if they are variable, more complex formulae will result. We see here that the absorption of a line spectrum is fundamentally different from the simple exponential absorption which is valid for a continuous spectrum. C. Pekeris (5) has first pointed out the importance of the square root law for atmospheric radiation and has also shown that it is experimentally fulfilled in the near infrared atmospheric water bands measured by Fowle.

By definition, the quantity A varies between zero and unity. The square root law is an approximation which becomes invalid for very small thicknesses, where the substitution of the approximate formula (4) in place of (1) is no longer legitimate; and also for very large thicknesses where neighboring lines overlap and where, therefore, the absorption is no longer the sum of the contributions of the individual lines. In fact, for large values of x, the absorption must asymptotically approach unity (fig. 1). It seems, however, a fairly good approximation to assume that the square root law holds up to the value A=1, while for still larger thicknesses A=1 remains valid. This schematic course of the fractional absorption is represented by the solid line in figure 1, while the broken line gives an idea of the true value of the absorption.

We come now to the numerical determination of the absorption. For reasons which will appear later, we shall divide the whole spectrum into three parts, the first ranging from the short wave end to about 10μ (1000 cm^{-1}), the second from about 10μ to about 20μ (500 cm^{-1}), and the third from there towards the long wave end. We start our investigation at the long wave side.

2. ABSORPTION BEYOND 20μ

All the lines and their intensities are tabulated in (2). The absorption is given by formula (6). The dependence on temperature which appears in (6) gives, however, not the whole variation of the absorption with temperature, since, as explained in (1) in more detail, the line intensities i_0 also depend somewhat upon temperature in a more complex manner. In order to calculate the absorption, the spectrum was divided into intervals of 25 cm^{-1} width each, and the expression $\sum\sqrt{i_0}$ was calculated for a number of different temperatures. In figure 2 the results are shown for two temperatures; the points are located in the middle of the respective intervals, and the crosses correspond to 300° abs. The ordinates are proportional to log A for a fixed thickness. The details of these calculations, which are too long to be reproduced here, are given in (6). The irregularities of the points in figure 2 are due to the irregular distribution of the water lines, which is not completely averaged out in the summation over the frequency intervals, although each interval contains a considerable number of lines. Now in order to have formulae which are practically applicable, the results have to be further smoothed out. The intensity of the absorption decreases in the mean exponentially for $\nu>300$ cm^{-1}. By a least-square method, a straight line was fitted to the ten points which lie beyond 300 cm^{-1} in the diagram. This was done for temperatures 200°, 220° . . . . up to 320°. The two lines for 220° and 300° are indicated in the figure. The results can be summed up in the following formula:

$$(7)\qquad \begin{cases} A=10^{a\nu+b}\sqrt{\dfrac{p}{p_0}}\sqrt{x} \\ a=-0.0108+8.4\times10^{-6}t \\ b=4.56 \\ \quad \text{for } \nu>300\ cm^{-1} \end{cases}$$

where t is the temperature in centigrade, $t=T-273$, and the optical thickness x is measured in grams of precipitable water.

For longer waves the absorption varies less rapidly and is also less dependent upon temperature. Since here no

very great precision is required, the black body emission being already rather small, we have simplified the formulae by assuming the absorption to be constant in each of two intervals and to be independent of temperature:

$$(8)\quad \begin{cases} A=26\sqrt{\frac{p}{p_0}}\sqrt{x} & (300\ cm^{-1}>\nu>175\ cm^{-1}) \\ A=42\sqrt{\frac{p}{p_0}}\sqrt{x} & (175\ cm^{-1}>\nu>75\ cm^{-1}) \end{cases}$$

The measurements in (**2**) do not go beyond 75 cm^{-1}; the absorption for still longer waves is, however, roughly known and may sufficiently well be approximated by extrapolating the second formula (8) down to 25 cm^{-1} and putting A=0 between 0 and 25 cm^{-1}.

For some purposes, an alternative approximation is more convenient. As seen from figure 2, the absorption is rather small beyond 375 cm^{-1} (the scale is logarithmic!) and is negligible in certain cases. The absorption intensities can fairly well be approximated by making A (not its logarithm) a linear function of ν between 175 and 375 cm^{-1}

$$(9)\quad \begin{cases} A=65.4+0.085t-0.164\nu \\ \text{for } 375\ cm^{-1}>\nu>175\ cm^{-1} \end{cases}$$

This function, plotted for 220° and 300°, appears in the figure as a curved line. For ν smaller than 175 cm^{-1}, the second formula (8) may be used.

3. ABSORPTION ON THE SHORT WAVE SIDE

We consider now the absorption caused by the strong water band which extends from 5μ to 8μ. Since this absorption covers a relatively smaller part than the one treated above, we can do with a less detailed analysis. The general conditions are, however, the same as before, the absorption being caused by numerous narrow lines, and the square root formula (6) applies. We have only to determine the constant which enters in (6) and its dependence on frequency. In order to do this, we have combined various measurements available in the literature.

It follows from the precise spectroscopic analysis that the band center is located at 1595 cm^{-1}, or, in sufficient approximation for our purposes, at 1600 cm^{-1}. The band is very approximately symmetrical with respect to the center. We can use the curve given by Hettner (**7**) to determine the *relative* intensity of the absorption as function of the frequency. A sufficiently good approximation is obtained if A decreases linearly at both sides of the center. The slope of these lines was determined by plotting the average absorption as given by Hettner on a frequency scale. The straight lines so determined cut the axis A=0 at 1250 cm^{-1} and 1950 cm^{-1}, respectively. However, as pointed out in (**1**), measurements made in steam should not be used to determine the *absolute* amount of the absorption under atmospheric conditions. For the latter purpose, the measurements of Fowle (**8**) made in the atmosphere are suitable. We shall first try to check the square root law in Fowle's measurements. For this purpose the values of A for various spectral intervals, as given by Fowle (**9**), are plotted with $\sqrt{x}$ as abscissa. This has been done in figure 3. It is seen that up to a certain thickness, namely 0.1 cm. of precipitable water, the measured points fall well on a straight line. Then the curve bends around and the following points lie on another straight line which does not go through the origin. It is difficult to determine the cause of this rather surprising phenomenon. One may presume that it is connected with the fact that the two sets of points are obtained experimentally by two different arrangements. The lower points correspond to a path of the light which remains inside the spectroscope itself, while for the measurement of the higher points an additional path of 117 m in air outside the spectroscope was required. Since there is a considerable amount of stray light which has to be taken into account as a correction, it was thought that this might be connected with the discontinuity which appears in figure 3. For the following computations, only the lower section of the curves was used. The three intervals 5–6μ, 6–7μ, and 7–8μ, can be used for the comparison. If the relative values of the absorption, as resulting from the relative slope of the

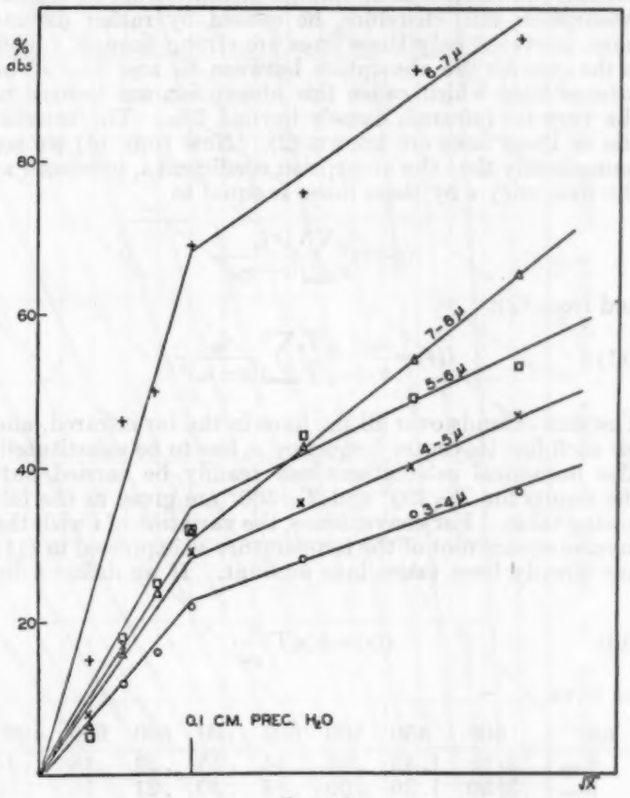


FIGURE 3.

lines, are compared with Hettner's relative values, a certain discrepancy appears. One may either average the three intervals for the comparison, or pick out one of them. It was thought that the middle interval 6–7μ which covers the center of the band was most suitable, since the absorption extends over a rather large range (up to 70 percent), and the experimental error involved should, therefore, be considerably smaller in this case than in the other cases. We have, for the interval 6–7μ, an absorption $A=2.2\sqrt{x}$. Comparing this with the relative variation of the absorption with frequency which results from Hettner's data, the following formulae were obtained:

$$(10)\quad \begin{cases} A=3.7\left(1-\frac{\nu-1600}{350}\right)\sqrt{\frac{p}{p_0}}\sqrt{x} \\ \text{for } 1950\ cm^{-1}>\nu>1600\ cm^{-1}; \\ A=3.7\left(1-\frac{1600-\nu}{350}\right)\sqrt{\frac{p}{p_0}}\sqrt{x} \\ \text{for } 1600\ cm^{-1}>\nu>1250\ cm^{-1}. \end{cases}$$

The variation of this absorption with temperature should be so small that it has been thought appropriate to neglect it completely.

4. ABSORPTION IN THE INTERMEDIATE REGION

The spectroscopic analysis carried out with great resolving power shows that there are only a few extremely weak water lines in the region between 8μ and 25μ. Nevertheless, an absorption of the atmosphere must be assumed in order to account for the measured amount of radiation coming in from the sky. We shall now investigate the way in which this radiation originates (**10**).

It results from formula (1) or formula (4) that each line extends in principle to an infinite distance from its center. Absorption can, therefore, be caused by rather distant lines, provided only these lines are strong enough. This is the case for the absorption between 8μ and 25μ. The intense lines which cause this absorption are located in the very far infrared, namely beyond 30μ. The intensities of these lines are known (**2**). Now from (4) we see immediately that the absorption coefficient i, produced at the frequency ν by these lines, is equal to

$$i(\nu)=\frac{\alpha}{\pi}\sum\frac{i_0}{(\nu-\nu_0)^2},$$

and from (2):

$$i(\nu)=\frac{\alpha_0 p}{\pi\ p_0}\frac{\sqrt{T_0}}{\sqrt{T}}\sum\frac{i_0}{(\nu-\nu_0)^2}. \tag{11}$$

The sum extends over all the lines in the far infrared, and for each line its center frequency ν_0 has to be substituted. The numerical calculations can readily be carried out; the results for $T=220°$ and $T=300°$ are given in the following table. For convenience, the variation of i with the inverse square root of the temperature as expressed in (11) has already been taken into account. If we define k by

$$i(\nu)=k(\nu,T)\frac{p}{p_0} \tag{13}$$

we have

cm^{-1}	400	450	500	600	700	800	900	1000
k_{220}	2.61	1.43	.96	.54	.35	.23	.18	.14
k_{300}	3.50	1.36	.90	.46	.30	.21	.15	.12

The values above 500 cm^{-1} are very well approximated by the formula

$$k=\frac{78{,}000-240t}{(\nu-200)^2},$$

which may also be extrapolated to larger values of ν than those contained in the table; t is the temperature in centigrade. This formula shows that the absorption has the same character as if it were produced by a single, very strong line located at 200 cm^{-1}. In principle a second term should be added to the one calculated above, namely the absorption caused by the band at 6 μ at great distances from its center. However, if this is done the absorption turns out to be negligible compared with the one given above.

It must now be particularly emphasized that *this absorption does not follow the square root law, but follows the ordinary absorption law* $I=I_0e^{-kz}$, and the values for the absorption coefficient given in the table have to be corrected for air pressure according to formula (13). An inspection of the black-body curve shows that this type of absorption is preponderant in the spectral range covered by atmospheric radiation. The absorption coefficient rises very rapidly towards longer waves. The square root absorption treated in Section 2, however, rises still more rapidly with increasing wavelength, and between 400 and 350 cm^{-1} the two absorption laws give values of comparable order of magnitude. It seems a proper approximation to use the exponential absorption law alone for $\nu>375$ cm^{-1} and to use from there on the square root law, for instance with the numerical values given in formula (9). On the short wave side, the exponential absorption law may be used up to 1250 cm^{-1}, while from there on the square root formula (10) becomes valid. In this way the whole spectral range of the heat radiation of the atmosphere is covered.

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PSYCHROMETRIC CHARTS

By JOHN G. ALBRIGHT

[Case School of Applied Science, Cleveland, Ohio]

The accompanying psychrometric charts, constructed by the author, have been used for some time and have proved to be very helpful and convenient where extreme accuracy is not desired. They were constructed from values given in *Psychrometric Tables* and *Relative Humidity, Centigrade Temperature*, publications of the United States Weather Bureau. The values given for a barometric pressure of 29 inches were used. From these charts the relative humidity, absolute humidity and dew point can be readily found from the wet- and dry-bulb values. Chart 1 is designed for use when the temperatures are given in Fahrenheit and Chart 2 is for reference when the temperatures are given in Centigrade.

The temperatures of the dry bulb are plotted along the horizontal direction and are represented by the vertical lines, the values of which are indicated at the top. The differences between the wet- and dry-bulb thermometer temperatures are plotted along the vertical direction and are represented by the horizontal lines, the values of which are indicated at the left. Relative humidities are represented by the solid lines that slope upward to the right; their values are indicated at the right margins. Absolute humidities are represented by the broken lines that slope upward more sharply to the right; their values are indicated at the bottom of the chart.

The procedure for obtaining the relative humidity, the absolute humidity, and the dew point from wet- and dry-bulb thermometer readings is given in the following example. If the dry-bulb thermometer reads 90° F. and the wet-bulb thermometer reads 80° F., giving a

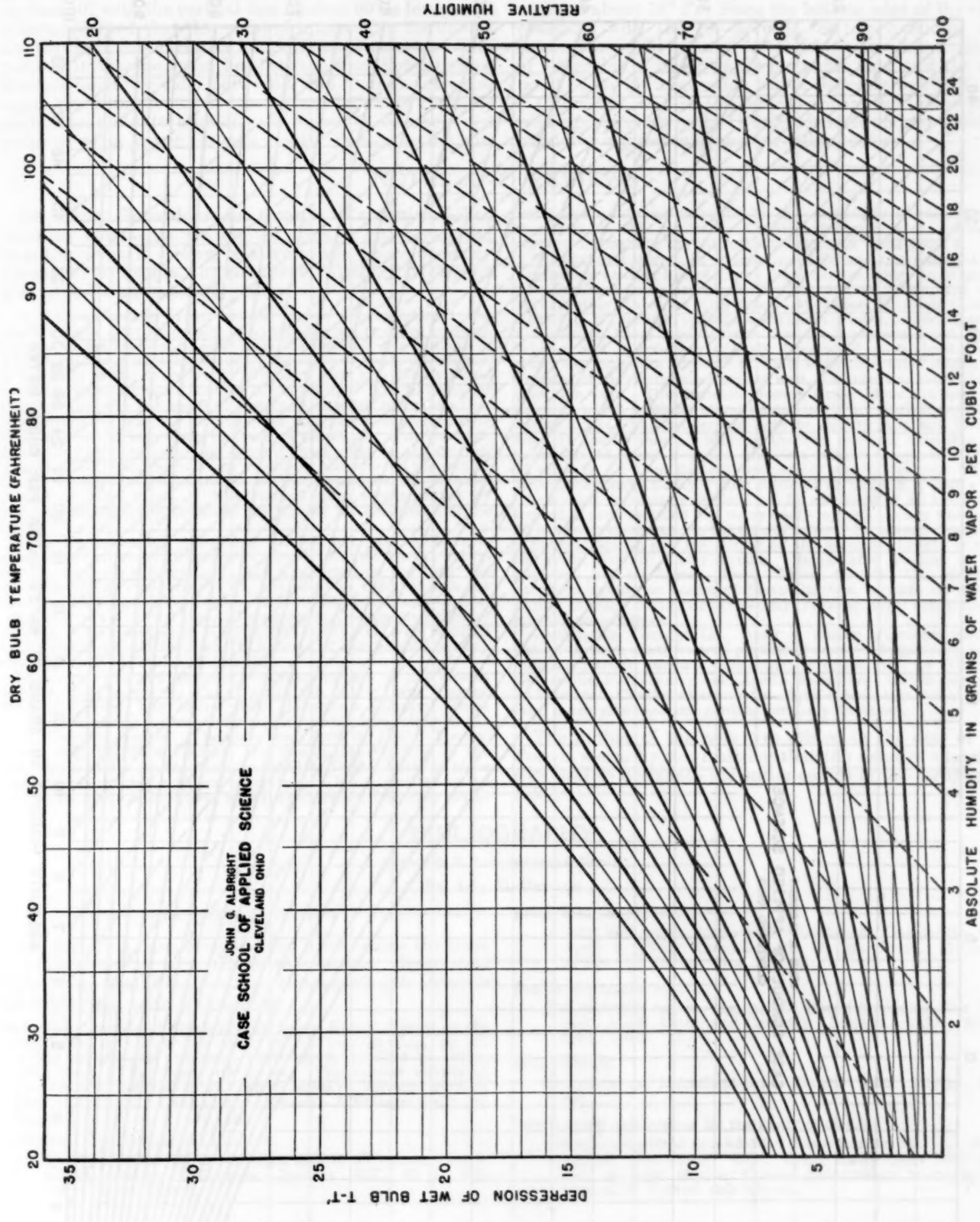
RELATIVE HUMIDITY
DRY BULB TEMPERATURE (FAHRENHEIT)
DEPRESSION OF WET BULB T-T'
ABSOLUTE HUMIDITY IN GRAINS OF WATER VAPOR PER CUBIC FOOT
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Chart 1.

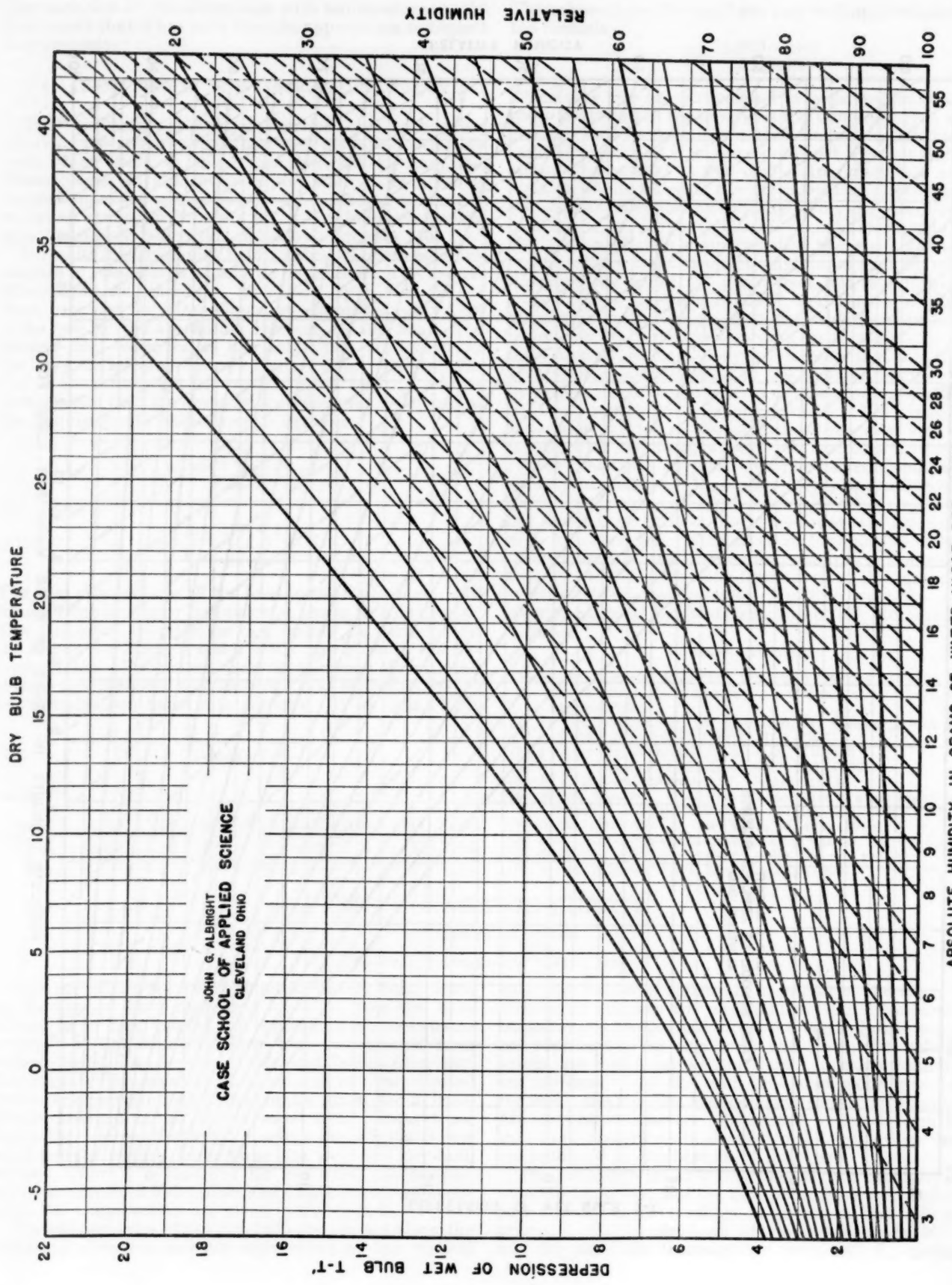
RELATIVE HUMIDITY
20
30
40
50
60
70
80
90
100
DRY BULB TEMPERATURE
40
35
30
25
20
15
10
5
0
-5
ABSOLUTE HUMIDITY IN GRAMS OF WATER VAPOR PER CUBIC METER
55
50
45
40
35
30
28
26
24
22
20
18
16
14
12
10
9
8
7
6
5
4
3
DEPRESSION OF WET BULB T-T'
22
20
18
16
14
12
10
8
6
4
2
JOHN G. ALBRIGHT
CASE SCHOOL OF APPLIED SCIENCE
CLEVELAND OHIO

Chart 2.

difference of 10° between the wet- and dry-bulb thermometer readings, the intersection of the horizontal line marked 10° with the vertical line marked 90° is found. It is then observed that this point of intersection lies upon a line that indicates a relative humidity of 65 percent. This point of intersection also lies between lines indicating an absolute humidity value between 9 and 10 grains of water vapor per cubic foot. If the interpolation is carefully made, the absolute humidity is found to be about 9.6 grains of water vapor per cubic foot. Passing to the bottom edge of the chart this value of the absolute humidity as determined is found to coincide with a dry-bulb temperature of about 76° F. Since the bottom edge of the chart coincides with the 100 percent relative humidity line, saturation would occur at 76° F. for an absolute humidity of 9.6 grains of water vapor per cubic foot, and the dew point of the air in question would therefore be 76° F.

Chart 2 is used in the same manner; the temperature readings are given in the Centigrade scale and the absolute humidity is given in grams per cubic meter.

NOTES AND REVIEWS

On Early Tornadoes in Georgia: Correction.—The following comments are quoted from a letter received from Col. John P. Finley, relative to the "Note on Early Tornadoes in Georgia," by George W. Mindling, MONTHLY WEATHER REVIEW, 66: 14, 1938:

In the preparation of my several papers on tornadoes I was required to be brief, especially as to tabulations, in order to lessen the cost of publication. Accordingly the location of a tornado or a hailstorm was usually indicated by the name of one town, county, or township in the entire track. To have gone into details would have very much increased the cost of publication. The 50 buildings recorded opposite the town of Toccoa, Ga., does not mean that these structures were all destroyed at that place, or even one of them, but somewhere along the path of the storm. For complete details in every instance, the student must refer to the original records of the Signal Service and voluntary observers of the period, on file in the Records Division of the United States Weather Bureau at Washington. These records were supplemented by newspaper clippings, collected at the time of the occurrence of the storms.

As to the paragraph concerning the tornado reported to have occurred at Davisboro, Washington County, Ga., at 6 p. m., February 18, 1884, my records show that it occurred on the 19th. In my Professional Paper No. XVI, published in 1885, and in the American Meteorological Journal of 1890 (State Tornado Charts) tornadoes were reported from 23 counties in Georgia on February 19, 1884. The tornadoes in Washington County, Ga., were reported to the Signal Service by John D. Roberts, of Sandersville, county seat, and by J. M. Minor, of Sun Hill.

EXTRACTS FROM THE MONTHLY WEATHER REVIEW OF THE SIGNAL SERVICE, UNITED STATES ARMY, APRIL 1880: At or near Toccoa, Stephens County, and Mount Airy, Habersham County. These counties are in the extreme NE. portion of Georgia, close to the South Carolina border. The date was April 3, 1880. Toccoa, county seat, Stephens County. In Washington County, in the east central portion of the State on April 4, 1880. Both of these dates were associated with low pressure area No. 1, central on the 3rd and 4th in lower Michigan, with the depression extending southward and conditions favorable to the occurrence of violent local storms in the SE. quadrant. Cautionary signals were ordered at stations throughout the entire Lake Region on April 3 and 4.

Violent local storms, in unusual numbers, occurred during April. Tornadoes, causing loss of life or doing serious injury to property, were reported from Georgia on the 3rd, 4th, and 24th, and from various other States, on other dates. At Dalton, Whitfield County, April 3, p. m., tornado passed 6 miles north of town, extending across Connasauga River into Murray County; 2 persons killed, many injured, and 18 houses completely demolished; path about 1 mile wide; two opposing currents of wind were observable during the progress of the storm, one from the west, the other and most violent from the east. This tornado crossed Grass Mountain near the point at which a similar storm passed in 1878. April 3, near midnight, tornado and waterspout between Mount Airy and Toccoa, Ga. It passed through Murray County, reaching Cherokee 100 miles distant about 2 a. m. Heaviest rainfall for years. About 12 miles of Air Line Railway washed out and bridge over Tugalo River, Stephens County. Hail reported as large as a man's fist. The county is sparsely settled, yet 50 dwellings of all kinds were leveled, 3 persons killed and many badly injured. A hog was found 40 feet from the ground in the fork of a tree. Its passage resembled a cloud of smoke and fire rolling on the ground. Length of path unknown; average about 1 mile. Remarkable amount of rain reported, but no figures given. Elbert County, Ga., south of Stephens County on border of South Carolina, tornado on April 3 passed through north part of county, blowing down many houses and the largest trees.

Washington County, Ga., April 4, during afternoon, tornado passed through southwestern portion of county, demolishing many buildings; track one-half mile wide; direction SW. to NE. At Gainesville, Hall County, Ga., April 4, hailstones 1 inch in diameter. At Savannah, Chatham County, Ga., April 4, hail 1½ inches in diameter; much glass broken; gardens seriously damaged.

The author of the note was misled in the case of the Toccoa storm by not realizing that the name of a locality was used to designate the entire course of the tornado.—*Editor.*

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[RICHMOND T. ZOCH, *in Charge of Library*]

By AMY D. PUTNAM

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

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87009—38——2

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SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, JUNE 1938

By CHARLES M. LENNAHAN

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at nine cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parenthesis). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (75th meridian time) and at noon (local mean solar time).

During June 1938 direct solar radiation intensities averaged above normal at Blue Hill and Madison, about normal at Lincoln, and below normal at Washington.

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

One half of the stations received an excess and the other half a deficiency of total solar and sky radiation during June 1938. Of the six stations showing an excess in May, New York is the only one which does not show an excess in June.

Polarization measurements were made on 6 days at Madison giving a mean value of 47.1 percent and a maximum of 55.3 percent on the 8th; both of these values are below the corresponding normals for the month.

TABLE 1.—*Solar radiation intensities during June 1938*

[Gram-calories per minute per square centimeter or normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
June 1	7.87	0.66	0.73	0.90	1.11	1.51					6.02
June 2	11.38				0.89	1.30					12.68
June 6	9.47	0.38	0.49	0.66	1.00						9.14
June 7	16.20	0.37	0.46	0.61	0.97						14.60
June 13	8.81	0.32	0.42	0.60	0.97						8.81
June 14	9.47				1.04						9.14
June 15	10.59				1.00						6.76
June 23	16.20					1.10					15.11
June 24	15.65					1.06					13.61
June 29	8.81					1.34					6.76
Means		0.43	0.52	0.69	1.00	1.26					
Departures		−.13	−.15	−.10	+.05	+.01					

MADISON, WIS.

June 2	10.21		0.94	1.08	1.24						8.18
June 7	7.04		0.98	1.14	1.31	1.48					5.79
June 8	6.50		0.87	1.02	1.24	1.47					7.04

TABLE 1.—*Solar radiation intensities during June 1938*—Continued

MADISON, WIS.—Continued

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
June 18	11.81	0.67	0.77	0.91	1.10						12.68
June 20	11.38	0.57	0.71	0.84	1.00	1.25					14.10
June 27	7.57		0.87	0.98	1.16						9.14
June 29	7.57	0.78									9.14
Means		0.67	0.86	1.00	1.18	1.40					
Departures		−.06	+.01	+.03	+.13	+.07					

LINCOLN, NEBR.

June 2	9.47	0.69	0.81	0.93	1.10		1.21				8.48
June 3	10.97						1.22				13.13
June 4	9.47	0.68	0.82	0.96	1.13	1.40	1.14	0.90	0.70	0.60	6.76
June 7	7.57	0.60	0.71	0.86	1.02	1.30					6.50
June 12	9.47				1.16						9.14
June 14	15.11				0.96						14.10
June 15	12.24	0.72	0.82	0.95	1.14	1.43	1.16				13.13
June 16	14.60						1.14				14.60
June 21	16.79						1.17				15.65
June 23	16.20					1.31	1.02				17.96
June 24	17.37		0.76	0.90	1.08	1.35					16.79
June 27	9.14	0.77	0.88	1.01	1.17	1.43	1.14				6.50
June 30	17.96						0.93				16.79
Means		0.69	0.80	0.94	1.10	1.37	1.13	0.90	0.70	0.60	
Departures		−.05	+.01	+.01	−.01	+.01	+.02	−.02	−.09	−.07	

BLUE HILL, MASS.

June 1	6.3	0.86	0.96	1.08	1.20	1.29	1.05	0.82			7.9
June 2	7.9			1.20	1.37	1.43	1.37	0.90			9.6
June 6	7.9		1.33	1.37	1.41	1.45	1.28	1.21			18.2
June 7	13.2		0.74	0.89	1.06		1.27				15.8
June 9	11.1		1.08	1.16	1.28	1.42					6.1
June 13	9.4					1.37					16.9
June 14	9.9				1.10	1.32					10.3
June 15	8.8					1.48	1.26				9.9
June 20	13.2				1.18	1.35	1.25				11.5
June 21	13.2				1.22	1.33					12.8
June 24	14.7				0.92	1.02					18.8
Means		(0.86)	1.03	1.14	1.19	1.35	1.25	0.98			
Departures		0.00	+.04	+.10	+.10	+.06	+.15	−.04			

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca	Newport
	Gram-calories per square centimeter																
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
June 4	527	614	594	542	474	744	493	659	445	461	462	487	548	649	736	513	575
June 11	522	514	633	465	456	708	492	554	512	516	520	528	462	475	499	472	448
June 18	423	621	582	533	423	721	518	520	555	432	537	516	637	516	681	524	506
June 25	420	415	564	411	373	704	528	436	498	377	(1)	559	340	654	623	334	386
	Departures of daily totals from normals																
June 4	+26	+99	+42	+93	+39	+77	+10	+77	−115	−43	−16	−57	+27	+74	+97	+45	
June 11	+24	+7	+84	+15	+14	+6	−2	−66	−52	+32	+30	−67	−46	−67	−37	−49	
June 18	−69	+90	−1	+61	−10	−3	−2	−154	−8	−12	+67	−88	+104	−28	+83	+7	
June 25	−101	−117	−37	−31	−69	−15	+67	−200	−63	−109	(1)	−34	−166	+79	+47	−140	
	Accumulated departures since Jan. 1																
	−9,573	−3,528	−1,918	+3,010	+581	−2,499	+3,710	−7,128	−2,436	−2,205	+4,480	−3,619	−1,911	+7,355	+8,253	+1,176	

[1] No record obtained due to instrumental trouble.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
	h m		°	°	°				
June 1	10 52	5914	−64.0	190.2	−6.5	242	-------	1	U. S. Naval.
		5913	−22.0	232.2	+4.0	73	-------	8	
		5911	−11.0	243.2	+28.0	339	-------	22	
		5910	+21.5	275.7	−8.0	145	-------	13	
		5909	+28.0	282.2	−21.0	48	-------	1	
		5905	+31.0	285.2	+20.0	36	-------	1	
		5907	+85.0	339.2	+19.0	145	1,028	2	
June 2	11 34	5917	−75.0	165.6	−19.5	97	-------	2	Do.
		5914	−49.5	191.1	−7.0	242	-------	4	
		5913	−7.5	233.1	+5.0	73	-------	18	
		5911	+2.5	243.1	+28.0	339	-------	23	
		5910	+37.0	277.6	−7.0	170	-------	15	
		5915	+39.0	279.6	+20.0	97	-------	10	
		5916	+39.5	280.1	+26.0	24	-------	2	
		5909	+42.0	282.6	−21.0	24	-------	1	
		5905	+46.0	286.6	+20.5	12	1,078	2	
June 3	8 27	5917	−63.0	166.0	−20.0	97	-------	6	Mt. Wilson.
		5914	−37.0	192.0	−7.0	267	-------	7	
		5918	−18.0	211.0	−5.0	36	-------	5	
		5913	+4.0	233.0	+5.0	145	-------	21	
		5911	+13.0	242.0	+28.0	388	-------	24	
		5916	+50.0	279.0	+26.0	12	-------	4	
		5910	+50.0	279.0	−7.0	73	-------	11	
		5915	+50.5	279.5	+21.0	73	-------	10	
		5909	+53.0	282.0	−20.0	24	-------	1	
		5905	+57.0	286.0	+20.5	12	1,127	1	
June 4	10 56	5919	−68.0	146.4	+37.0	6	-------	1	U. S. Naval.
		5917	−48.0	166.4	−20.0	97	-------	6	
		5914	−23.0	191.4	−7.0	291	-------	8	
		5918	−4.0	210.4	−5.0	73	-------	8	
		5913	+21.0	235.4	+4.0	145	-------	14	
		5911	+28.0	242.4	+28.0	291	-------	18	
		5916	+62.0	276.4	+25.0	12	-------	2	
		5915	+62.0	276.4	+21.0	36	-------	2	
		5910	+64.0	278.4	−7.0	73	-------	2	
		5905	+70.5	284.9	+21.0	12	1,036	1	
June 5	13 48	5921	−78.0	121.6	+13.5	339	-------	4	Do.
		5919	−54.0	145.6	+37.0	24	-------	3	
		5917	−31.0	168.6	−19.0	97	-------	9	
		5914	−8.0	191.6	−7.0	218	-------	5	
		5918	+11.0	210.6	−5.0	48	-------	5	
		5913	+35.0	234.6	+4.0	145	-------	7	
		5911	+42.0	241.6	+29.0	145	-------	10	
		5910	+77.0	276.6	−7.0	6	1,022	2	
June 6	10 58	5923	−85.0	102.9	−10.5	97	-------	1	Do.
		5921	−67.0	120.9	+13.0	582	-------	20	
		5922	−58.0	129.9	+12.0	24	-------	2	
		5919	−41.5	146.4	+37.0	97	-------	8	
		5917	−19.5	168.4	−19.0	170	-------	22	
		5920	−0.5	187.4	+23.0	6	-------	1	
		5914	+5.0	192.9	−6.5	218	-------	10	
		5913	+48.0	235.9	+4.0	121	-------	9	
		5911	+55.0	242.9	+28.0	145	1,460	7	
June 7	11 3	5923	−71.0	103.7	−10.5	145	-------	2	Do.
		5926	−58.0	116.7	+21.0	24	-------	5	
		5921	−53.0	121.7	+14.0	679	-------	28	
		5922	−44.0	130.7	+12.0	48	-------	7	
		5919	−30.0	144.7	+36.5	85	-------	7	
		5925	−12.0	162.7	+19.0	24	-------	7	
		5917	−7.0	167.7	−19.0	194	-------	14	
		5924	−1.0	173.7	+19.0	12	-------	4	
		5920	+12.0	186.7	+22.0	12	-------	2	
		5914	+17.5	192.2	−7.0	194	-------	8	
		5913	+62.0	236.7	+4.0	48	-------	4	
		5911	+75.0	249.7	+26.0	73	1,538	3	
June 8	11 16	5923	−58.0	103.3	−10.5	97	-------	1	Do.
		5926	−46.0	115.3	+21.0	24	-------	7	
		5921	−40.0	121.3	+14.0	921	-------	57	
		5928	−33.0	128.3	+25.0	24	-------	2	
		5922	−29.0	132.3	+12.0	73	-------	9	
		5919	−17.0	144.3	+36.5	97	-------	9	
		5925	−0.5	160.8	+19.0	36	-------	7	
		5917	+6.0	167.3	−19.5	170	-------	10	
		5920	+23.0	184.3	+23.0	48	-------	7	
		5914	+31.0	192.3	−7.0	242	-------	7	
		5927	+69.0	230.3	−6.0	48	1,780	4	
June 9	11 1[illegible]	5923	−44.0	104.1	−10.5	73	-------	5	Do.
		5926	−32.0	116.1	+21.0	36	-------	8	
		5921	−27.0	121.1	+14.0	727	-------	58	
		5922	−15.0	133.1	+11.0	97	-------	9	
		5919	−6.0	142.1	+37.0	36	-------	4	
		5925	+13.0	161.1	+19.5	12	-------	4	
		5917	+19.0	167.1	−19.0	97	-------	8	
		5920	+37.0	185.1	+23.0	97	-------	9	
		5914	+44.0	192.1	−7.0	218	-------	7	
		5927	+83.0	231.1	−6.0	97	1,490	3	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
	h m		°	°	°				
June 10	14 16	5932	−78.0	55.2	−16.5	24	-------	1	U. S. Naval.
		5929	−65.0	68.2	+16.0	18	-------	2	
		5923	−29.5	103.7	−10.5	36	-------	3	
		5921	−12.0	121.2	+14.0	436	-------	44	
		5922	+3.0	136.2	+12.0	97	-------	6	
		5919	+9.0	142.2	+37.0	12	-------	4	
		5917	+35.0	168.2	−19.0	97	-------	6	
		5920	+51.0	184.2	+23.0	145	-------	9	
		5914	+60.0	193.2	−7.0	206	1,071	2	
June 11	10 54	5932	−65.0	56.8	−16.0	24	-------	1	Do.
		5929	−53.0	68.8	+17.0	36	-------	9	
		5929	−53.0	68.8	+14.0	6	-------	1	
		5921	0.0	121.8	+15.0	436	-------	46	
		5930	+7.0	128.8	−25.0	48	-------	13	
		5922	+15.0	136.8	+12.0	61	-------	2	
		5917	+42.0	163.8	−19.5	24	-------	5	
		5917	+50.0	171.8	−19.5	48	-------	4	
		5920	+63.0	184.8	+23.0	194	-------	8	
		5914	+71.0	192.8	−7.5	194	1,071	2	
June 12	13 4	5934	−86.0	21.4	+7.0	291	-------	1	Do.
		5933	−67.0	40.4	+15.0	6	-------	1	
		5932	−51.0	56.4	−16.0	24	-------	4	
		5931	−49.0	58.4	−19.0	6	-------	2	
		5929	−39.0	68.4	+17.0	73	-------	5	
		5921	+15.0	122.4	+15.0	436	-------	52	
		5930	+21.0	128.4	−25.0	73	-------	12	
		5922	+30.0	137.4	+12.0	61	-------	2	
		5917	+64.0	171.4	−19.5	48	-------	2	
		5920	+80.0	187.4	+24.0	97	1,115	5	
June 13	11 6	5934	−71.0	24.2	+6.0	485	-------	1	Do.
		5932	−38.0	57.2	−17.0	24	-------	2	
		5931	−36.0	59.2	−20.0	24	-------	4	
		5929	−29.0	66.2	+17.0	24	-------	3	
		5921	+29.0	124.2	+16.0	582	-------	45	
		5930	+36.0	131.2	−25.0	36	-------	2	
		5922	+42.0	137.2	+13.0	48	1,223	2	
June 14	11 0	5938	−78.0	4.0	+7.0	6	-------	1	Do.
		5934	−59.0	23.0	+5.0	436	-------	1	
		5936	−44.0	38.0	+21.0	73	-------	7	
		5933	−40.0	42.0	+12.0	24	-------	4	
		5932	−25.0	57.0	−17.0	24	-------	10	
		5931	−23.0	59.0	−19.0	12	-------	1	
		5921	+42.0	124.0	+16.0	582	-------	60	
		5922	+55.0	137.0	+13.0	24	-------	1	
		5935	+60.0	142.0	+5.0	24	1,205	7	
June 15	11 9	5938	−63.0	5.7	+7.0	6	-------	1	Do.
		5934	−45.0	23.7	+5.0	339	-------	3	
		5936	−30.0	38.7	+21.0	24	-------	8	
		5933	−27.0	41.7	+12.0	36	-------	4	
		5932	−12.0	56.7	−16.0	6	-------	2	
		5931	−10.5	58.2	−19.5	24	-------	4	
		5937	+30.0	98.7	−14.0	12	-------	2	
		5921	+55.0	123.7	+15.0	436	-------	39	
		5922	+69.0	137.7	+13.0	12	895	1	
June 16	14 50	5939	−79.0	334.4	+6.0	97	-------	10	Mt. Wilson.
		5934	−30.0	23.4	+5.0	339	-------	1	
		5936	−14.0	39.4	+20.0	24	-------	10	
		5933	−13.0	40.4	+13.0	73	-------	13	
		5932	+3.0	56.4	−16.0	48	-------	11	
		5931	+4.0	57.4	−18.0	24	-------	7	
		5937	+43.0	96.4	−13.0	36	-------	4	
		5921	+70.0	123.4	+15.0	436	1,077	20	
June 17	11 13	5939	−69.0	333.2	+5.0	303	-------	6	U. S. Naval.
		5941	−37.0	5.2	+13.0	12	-------	2	
		5934	−19.0	23.2	+5.0	303	-------	3	
		5933	−1.0	41.2	+13.0	61	-------	8	
		5936	−1.0	41.2	+19.5	12	-------	2	
		5932	+16.0	58.2	−17.0	73	-------	12	
		5940	+28.5	70.7	+12.0	24	-------	3	
		5921	+85.0	127.2	+13.0	194	982	2	
June 18	12 30	5939	−55.0	333.3	+5.0	485	-------	28	Do.
		5934	−5.0	23.3	+5.0	388	-------	5	
		5933	+13.0	41.3	+13.0	6	-------	6	
		5932	+30.0	58.3	−19.0	36	915	12	
June 19	13 26	5942	−66.0	308.5	+7.0	48	-------	1	Do.
		5939	−39.0	335.5	+5.0	727	-------	17	
		5943	−27.0	347.5	−8.0	24	-------	2	
		5934	+10.0	24.5	+5.0	436	-------	2	
		5932	+43.0	57.5	−19.0	24	1,259	4	
June 20	9 43	5942	−53.0	310.3	+8.0	36	-------	3	Mt. Wilson.
		5939	−26.0	337.3	+6.0	970	-------	45	
		5943	−14.0	349.3	−7.0	36	-------	6	
		5934	+22.0	25.3	+6.0	412	-------	10	
		5944	+39.0	42.3	+21.0	73	-------	5	
		5932	+57.0	60.3	−17.0	48	1,575	4	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
	h m		°	°	°				
June 21	13 8	5942	−37.0	311.2	+7.0	24	-------	4	U. S. Naval.
		5948	−15.0	333.2	−25.0	24	-------	7	
		5946	−15.0	333.2	+22.0	73	-------	16	
		5947	−13.0	335.2	+13.0	48	-------	10	
		5939	−12.0	336.2	+6.0	970	-------	50	
		5945	−8.0	340.2	−20.0	24	-------	6	
		5934	+37.0	25.2	+6.0	339	-------	5	
		5953	+51.0	39.2	+16.0	24	-------	2	
		5944	+53.0	41.2	+20.0	97	1,623	6	
June 22	13 27	5948	−2.0	332.8	−25.0	12	-------	1	Do.
		5946	−0.5	334.3	+22.0	291	-------	22	
		5939	+1.5	336.3	+6.0	824	-------	62	
		5947	+2.0	336.8	+13.0	12	-------	1	
		5945	+7.0	341.8	−20.0	48	-------	7	
		5934	+50.5	25.3	+5.0	388	-------	1	
		5944	+65.0	39.8	+20.0	16	1,591	3	
June 23	11 12	(*)	−11.0	311.8	+7.0	6	-------	3	Do.
		5946	+12.0	334.8	+22.0	436	-------	20	
		5939	+14.0	336.8	+6.0	679	-------	50	
		5945	+19.0	341.8	−20.5	97	-------	7	
		5949	+41.5	4.3	+6.0	6	-------	2	
		5934	+63.0	25.8	+5.0	388	1,612	2	
June 24	10 28	5951	+11.0	321.0	+7.0	12	-------	2	Do.
		5946	+24.0	334.0	+22.0	485	-------	25	
		5939	+26.0	336.0	+6.0	533	-------	45	
		5945	+32.0	342.0	−20.0	48	-------	6	
		5950	+39.0	349.0	−7.0	12	-------	2	
		5934	+77.0	27.0	+5.0	388	1,478	1	
June 25	11 3	5952	+9.0	305.4	+7.0	6	-------	1	Do.
		5946	+37.0	333.4	+22.0	436	-------	20	
		5939	+40.0	336.4	+6.0	533	-------	32	
		5945	+43.0	339.4	−21.0	48	-------	7	
		5950	+53.0	349.4	−8.0	24	1,047	4	
June 26	13 8	5957	−81.0	201.0	−11.5	291	-------	7	Do.
		5956	−60.0	222.0	+27.0	48	-------	6	
		5955	−48.0	234.0	−8.0	6	-------	1	
		5954	−12.5	269.5	+19.0	48	-------	4	
		5953	−3.0	279.0	−8.0	12	-------	2	
		5946	+52.0	334.0	+22.0	436	-------	16	
		5939	+55.0	337.0	+6.0	436	1,277	11	
June 27	9 5	5962	−78.0	193.0	−7.0	194	-------	1	Mt. Wilson.
		5957	−69.0	202.0	−11.0	436	-------	15	
		5961	−58.0	213.0	−21.0	48	-------	5	
		5956	−50.0	221.0	+27.0	73	-------	14	
		5960	−33.0	238.0	+3.0	36	-------	5	
		5959	−27.0	244.0	−7.0	48	-------	10	
		5954	+1.0	272.0	+20.0	48	-------	2	
		5953	+8.0	279.0	−7.0	36	-------	5	
		5946	+65.0	336.0	+24.0	533	-------	12	
		5939	+69.0	340.0	+7.0	436	1,888	14	
June 28	8 58	5962	−64.0	193.8	−7.0	194	-------	1	Do.
		5957	−55.0	202.8	−10.5	436	-------	20	
		5961	−45.0	212.8	−21.0	242	-------	8	
		5956	−37.0	220.8	+27.0	121	-------	14	
		5960	−19.0	238.8	+3.0	36	-------	9	
		5959	−13.0	244.8	−7.0	61	-------	10	
		5954	+14.0	271.8	+19.0	36	-------	2	
		5946	+78.0	335.8	+23.0	436	-------	5	
		5939	+79.0	336.8	+7.0	97	1,659	5	

*Not numbered.

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
	h m		°	°	°				
June 29	10 58	5966	−69.0	174.5	−25.0	6	-------	1	U. S. Naval.
		5962	−48.0	195.5	−7.5	194	-------	1	
		5957	−39.5	204.0	−12.0	436	-------	40	
		5961	−30.0	218.5	−22.0	533	-------	28	
		5956	−23.0	230.5	+27.0	145	-------	11	
		5960	−3.0	240.5	+3.0	36	-------	9	
		5959	+4.0	247.5	−7.0	97	-------	13	
		5954	+32.0	275.5	+17.0	24	-------	2	
		5965	+35.0	278.5	+7.0	6	-------	2	
		5964	+58.0	301.5	−7.0	6	-------	3	
		5963	+66.0	309.5	+9.0	97	-------	7	
		5946	+88.0	331.5	+22.0	48	1,628	2	
June 30	11 11	5962	−34.5	195.6	−8.0	194	-------	1	Do.
		5957	−25.0	205.1	−11.5	436	-------	46	
		5961	−16.0	214.1	−22.0	533	-------	37	
		5956	−10.0	220.1	+27.0	145	-------	11	
		5960	+10.0	240.1	+3.0	36	-------	4	
		5959	+17.0	247.1	−7.0	97	-------	11	
		5963	+78.0	308.1	+9.0	12	1,453	2	

Mean daily area for 30 days=1,307.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR JUNE 1938

[Dependent alone on observations at Zurich]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich Switzerland]

June 1938	Relative numbers	June 1938	Relative numbers	June 1938	Relative numbers
1	113	11	*b* 106	21	*Ec* 103
2	*a* 100	12	99	22	*ab* 101
3	*a* 107	13	*d* ——	23	98
4	103	14	----------	24	87
5	*d* 91	15	87	25	76
6	*Eac* 84	16	*d* 76	26	72
7	*Mc* 134	17	76	27	*EEccdd* 108
8	*Wac* 139	18	*a* 56	28	106
9	115	19	69	29	128
10	*a* ——	20	76	30	119

Mean, 27 days=97.4.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE in Charge]

By B. FRANCIS DASHIELL

Mean free-air data, for the month of June 1938, based on a total of 817 airplane and radiometeorograph observations, are given in table 1. This information includes the basic meteorological elements of barometric pressure (P), temperature (T), and relative humidity (R.H.), recorded at certain geometric heights.

These "means" are computed by the customary method of differences, and are omitted when less than 15 observations have been made at the surface and less than 5 at a standard height. However, at those standard heights within the limits of the monthly vertical range of the tropopause, at least 15 observations are required. Further details will be found under "Aerological Observations," appearing in the January 1938, MONTHLY WEATHER REVIEW.

Chart I, published elsewhere in this REVIEW, shows the departures of mean surface temperatures from normal during June. These departures were moderate over most of the United States, but reached above-normal maxima over the Northwestern States (except on the Pacific coast itself), the northern Rocky Mountains, New England, and western Texas. The greatest departure above normal was +4.1° F. at Walla Walla, Wash. In the southeastern states and Ohio Valley temperatures were slightly below normal, as compared to an above-normal departure in May; the largest departure below normal (−3.1° F.) occurred at Pittsburgh, Pa.

The highest mean free-air temperature (°C.) for June (table 1) prevailed over Kelly Field, Tex., at the surface; over Pensacola, Fla., at 0.5 kilometer; Oklahoma City,

Okla., and Kelly Field, Tex., at 1 kilometer; El Paso, Tex., at 1.5, 2, 2.5, 3, and 4 kilometers; and over Kelly Field, Tex., at 5 kilometers. The highest temperature recorded at any level above the surface was 23.1° C. over Kelly Field, Tex., at 0.5 kilometer.

Low temperatures existed generally over the northern and northeastern states, but were seasonally warmer than during the preceding month of May. Temperatures for the entire United States were lowest over Sault Ste. Marie, Mich., at all levels, except 4 kilometers, and a minimum of −10.4 °C. was reached at 5 kilometers. The lowest at 4 kilometers occurred over Lakehurst, N. J. Temperatures at all stations were higher than those observed the previous month; the closest approach to the May temperature being over Burbank, Calif., at 0.5 kilometer.

The mean free-air barometric pressures (in millibars) are shown in table 1. Entered on an isobaric chart they indicated that a statistical center of low atmospheric pressure prevailed east of the north-central states. It was located over Sault Ste. Marie, Mich., at all levels above 1 kilometer. During the preceding month of May this center was located more to the east, over Boston, Mass., but in June it was identical to the condition which prevailed in April, except that June pressures generally were higher.

In the lower levels a low-pressure area also was centered over Burbank, Calif. A slight tendency toward low pressure was noted over Salt Lake City, Utah, up to 3 kilometers. A belt of low pressure at 5 kilometers extended in an east-west direction across the United States from Boston, Mass., to Spokane, Wash., and from Washington, D. C., to Oakland, Calif. High pressures existed generally over the southeast at all levels up to 2.5 kilometers, particularly over Norfolk, Va., Maxwell Field, Ala., and Pensacola, Fla. Above 2.5 kilometers high pressures prevailed farther to the southwest; over Barksdale Field, La., Kelly Field, Tex., and El Paso, Tex. Pressure also was high over Seattle, Wash., up to 2 kilometers, and only relatively high above that level.

The free-air relative humidity, shown in table 1, was lowest at the surface over the southern Rocky Mountain region; over the upper Mississippi Valley at 0.5 kilometer; over California and the Middle Atlantic States at 1 and 1.5 kilometers; over the southwestern and southeastern States at 2 and 2.5 kilometers; over the entire far west, and southeastern and upper Mississippi Valley States at 3 kilometers; and over southern California, Florida, and the Great Lakes at 4 and 5 kilometers. These were marked changes from those existing in May when humidities were lowest over western Texas and the Middle Atlantic States at all levels.

During June the lowest humidities recorded at all levels above 1 kilometer were found in California over Oakland, Burbank, and San Diego. Above 3 kilometers the humidity was also low over Pensacola, Fla., and Maxwell Field, Ala. High humidities prevailed over the north Atlantic States (Boston, Mass., Lakehurst, N. J., and Washington, D. C.) at all levels, and over the Rocky Mountains at 4 kilometers (Billings, Mont.) and 5 kilometers (Cheyenne, Wyo.).

Free-air resultant wind directions and velocities, based on pilot-balloon observations made near 5 a. m. (75th meridian time), during the month of June 1938, are shown in table 2. While these resultants indicated a generally normal trend over most of the United States, there were several noteworthy exceptions.

Over the Pacific northwest sharp departures from normal resultant directions at all levels occurred over Medford, Oreg., and Seattle, Wash. The former was outstanding for the entire country. Elsewhere, unusual departures were noted at Houston, Tex., Sault Ste. Marie, Mich., Pensacola, Fla., Newark, N. J., and Albuquerque, N. Mex. On the other hand, at Omaha, Nebr., Chicago, Ill., and Cheyenne, Wyo., small departures were recorded, and the resultant winds remained very close to the normal at all levels.

Greatest variations in direction at all levels shifted from Seattle, Wash., where they were recorded in May, south to Medford, Oreg., in June. At the surface the resultant wind was south of normal, i. e., when considered as being rotated in a counterclockwise direction. But between 0.5 and 1 kilometer, the wind became normal, then, up to 5 kilometers, all directions were north of normal when rotated in a clockwise direction. Above 1 kilometer a uniform northerly increase in departure from normal was noted at all levels until there was a difference of 123° at 2.5 kilometers. These resultant directions for June, at all levels beginning with the surface, were: 235°, 273°, 303°, 338°, 14°, 10°, 290°, 293°, and 292°, as compared to the established normals of 287°, 283°, 299°, 305°, 288°, 247°, 241°, 257°, and 264°, respectively.

At Seattle, Wash., departures occurred at 1 and 1.5 kilometers, where differences of 103° and 74°, respectively, were noted. Resultant departures at Seattle, Wash., during June were greater, or north of normal, at all levels. A large southerly departure from normal occurred over San Diego, Calif., at 0.5 kilometer, but resultant winds for levels exceeding 1 kilometer could not be obtained in June. Elsewhere in the United States all observations reached 3 kilometers; only 9 stations failed to reach 5 kilometers.

Pensacola, Fla., had northerly departures from normal between the 0.5- and 2.5-kilometer levels. But, over Key West, Fla., all departures were south of normal up to 2 kilometers, and then north of normal up to 5 kilometers. At Newark, N. J., and St. Louis, Mo., all June resultants were north of normal when rotated clockwise, and at Boston, Mass., Atlanta, Ga., Billings, Mont., and Cheyenne, Wyo., they were south of normal when rotated counterclockwise.

Greatest differences in resultant directions from the normal occurred at Sault Ste. Marie, Mich., on the surface; over San Diego, Calif., at 0.5 kilometer; over Seattle Wash., at 1 kilometer and 1.5 kilometers; over Albuquerque, N. Mex., at 2 kilometers; over Medford, Oreg., at 2.5 and 3 kilometers; over Newark, N. J., at 4 kilometers; and over Houston, Tex., at 5 kilometers. Of all the resultant winds for June over the United States, 36 percent were from an easterly direction at the surface, tapering off to 4 percent at 2.5, 3, and 4 kilometers. At 5 kilometers all directions were westerly, but divided equally between the southwest and northwest quadrants.

Resultant wind velocities for June were slightly above normal over the Pacific Coast States up to 2.5 kilometers, then below normal at the higher levels. They were above normal, too, in the South, except over Houston, Tex., at all levels, and below normal over the North Atlantic States above 0.5 kilometer. These velocities were below normal almost generally elsewhere at and above 1 kilometer, except over Salt Lake City, Utah, and Albuquerque, N. Mex., at 5 kilometers. The largest

below-normal departures in wind velocities were noted over Newark, N. J., at 2, 2.5, 3, and 4 kilometers; at 3 kilometers the difference being 5.9 m. p. s., the greatest for the United States. Other marked departures in velocity above the 2 kilometer level occurred over Boston, Mass., Sault Ste. Marie, Mich., Washington, D. C., and Pensacola, Fla.

Maximum wind velocities are shown in table 3. At Modena, Utah, on the 19th, a velocity of 63.3 m. p. s. from the south was observed at 2,470 meters, and at 30 meters higher (2.5 kilometers) a velocity of 58 m. p. s. High velocities also were recorded over northern stations between Spokane, Wash., and Boston, Mass., on the 7th and 8th.

TABLE 1.—*Mean free-air barometric pressure (P) in mb., temperature (T) in °C., and relative humidities (R. H.), in percent, obtained by airplanes and radiometeorographs during June 1938*

Stations	Altitude (meters) m. s. l.																											
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of obs.	P	T	R. H.	P	T	R. H.	P	T.	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.	P	T	R. H.
Barksdale Field, La.[1] (52 m)	29	1,010	22.1	91	959	22.7	73	905	20.2	72	854	17.3	71	805	14.5	62	758	11.8	57	714	9.0	54	632	2.9	49			
Billings, Mont.[2] (1,090 m)	29	891	14.4	69							849	15.5	52	800	12.7	51	753	9.3	55	709	6.1	57	626	−0.3	57	552	−7.2	56
Boston, Mass.* (5 m)	24	1,014	16.8	84	957	16.3	74	903	14.1	70	851	11.3	67	801	8.3	61	753	5.6	58	708	3.1	54	626	−2.0	48	551	−7.2	42
Cheyenne, Wyo.[2] (1,873 m)	29	813	10.9	79										801	13.0	64	754	12.7	52	711	9.8	51	628	1.9	55	555	−6.4	65
Coco Solo, C. Z.[3] (15 m)	22	1,009	24.7	95	955	23.4	86	902	20.9	85	851	18.3	84	802	15.8	82	756	13.5	76	712	11.0	72	631	4.8	74	558	−1.7	81
El Paso, Tex.[2] (1,193 m)	30	880	22.4	46							850	22.9	42	802	20.3	41	756	16.9	42	713	13.3	43	632	4.9	48	558	−3.2	56
Fargo, N. Dak.[2] (274 m)	30	981	13.8	84	955	16.5	64	901	14.7	59	849	12.3	59	799	9.2	60	752	6.4	57	707	3.8	53	624	−1.9	47	550	−7.9	47
Kelly Field, Tex.[1] (206 m)	16	991	24.9	80	959	23.1	88	905	20.5	78	853	18.2	70	805	15.3	67	758	12.4	58	714	9.3	57	632	3.1	57	550	−2.9	56
Lakehurst, N. J.[2] (39 m)	19	1,012	17.1	86	958	18.3	66	903	15.0	63	851	11.4	65	802	7.6	62	754	4.8	58	709	1.8	62	624	−5.0	58			
Maxwell Field, Ala.[1] (52 m)	29	1,010	22.4	82	960	22.7	63	906	19.3	68	855	16.1	66	806	12.8	66	758	9.7	62	714	7.3	51	631	1.5	47	557	−4.3	35
Mitchel Field, N. Y.[1] (29 m)	25	1,013	17.0	91	959	17.8	68	904	15.9	66	852	13.0	65	803	9.8	67	755	6.9	66	710	4.3	66	628	−0.6	57			
Nashville, Tenn.[2] (180 m)	30	995	19.3	87	959	21.2	68	905	18.6	72	853	15.4	73	804	12.7	62	757	10.1	55	713	7.1	54	631	1.0	52	556	−4.9	45
Norfolk, Va.[3] (10 m)	21	1,019	20.8	89	963	20.7	65	909	18.5	58	856	15.7	58	808	12.6	61	760	9.9	59	716	7.2	55	632	0.4	53	558	−6.0	41
Oakland, Calif.[3] (2 m)	30	1,013	12.7	85	955	13.9	76	901	20.7	39	849	18.7	32	801	15.4	32	754	11.7	32	710	8.4	33	627	1.0	38	554	−6.1	40
Oklahoma City, Okla.[2] (391 m)	30	970	20.5	86	958	21.9	73	904	20.5	68	853	17.7	71	805	15.1	65	757	12.2	61	713	9.3	57	631	2.7	54	557	−4.0	45
Omaha, Nebr.[2] (300 m)	30	980	18.6	80	957	20.0	69	903	18.5	63	852	15.6	64	802	12.5	65	755	9.9	62	711	7.1	59	628	0.9	56	555	−5.6	50
Pearl Harbor, T. H.[3] (6 m)	30	1,016	22.2	83	960	20.9	77	906	17.9	81	853	15.5	76	805	13.7	64	757	12.3	51	713	10.8	38	632	7.0	28	560	2.5	26
Pensacola, Fla.[3] (13 m)	26	1,016	22.3	94	961	23.0	72	908	20.1	68	856	16.5	68	807	13.3	67	759	10.8	56	715	8.3	45	632	2.4	39	558	−3.6	35
St. Thomas, V. I.[3] (8 m)	29	1,018	26.5	75	962	21.4	83	908	17.9	86	856	15.1	82	808	13.2	72	760	11.4	57	716	8.5	53	634	2.6	51	560	−3.2	52
Salt Lake City, Utah[2] (1,288 m)	30	869	15.7	54							848	19.1	42	800	16.9	39	753	13.3	40	710	9.8	42	628	2.2	51	554	−5.3	56
San Diego, Calif.[3] (10 m)	28	1,013	17.3	79	956	13.5	88	902	16.8	61	850	18.2	41	802	16.4	31	755	13.3	28	711	10.2	26	629	3.9	24	556	−3.5	24
Sault Ste. Marie, Mich.[2] (221 m)	30	988	10.8	90	956	13.2	70	900	11.0	70	847	8.6	69	798	5.4	72	749	3.0	70	705	1.0	57	621	−4.2	46	547	−10.4	43
Scott Field, Ill.[1] (135 m)	24	1,002	17.1	89	960	19.8	63	905	16.9	63	853	13.8	66	804	11.2	63	757	9.1	55	712	6.7	50	629	0.6	50	556	−5.4	35
Seattle, Wash.[3] (10 m)	19	1,018	17.9	59	961	12.9	72	906	12.2	60	853	10.8	52	803	8.3	53	755	5.9	47	711	3.3	43	627	−2.7	45			
Selfridge Field, Mich.[1] (177 m)	30	994	15.1	84	957	17.5	64	903	14.7	64	850	11.2	66	801	8.2	70	753	5.5	65	709	3.4	57	625	−1.5	52	551	−7.5	49
Spokane, Wash.[3] (597 m)	30	944	13.6	72				901	17.4	47	849	14.7	47	800	11.3	50	753	8.2	50	709	5.1	52	625	−1.1	49	552	−7.2	45
Washington, D. C.[3] * (13 m)	29	1,016	18.6	84	958	17.2	73	904	15.3	67	851	12.6	66	803	9.4	69	754	6.9	70	711	4.4	68	627	−1.6	60	552	−7.5	53
Wright Field, Ohio[1] (244 m)	29	987	15.7	87	958	18.1	71	903	16.8	66	852	13.6	70	802	10.9	65	755	8.1	64	711	6.0	52	628	0.6	47	554	−5.2	45
Burbank, Calif.* (220 m)	30	987	13.5	90	954	13.1	87	900	15.8	62	849	15.6	48	800	14.5	37	754	12.2	32	710	9.3	31	628	2.9	26	554	−4.0	23
Chicago, Ill.[3] (187 m)	30	994	16.5	83	958	18.0	65	903	15.5	65	851	12.2	69	802	9.4	66	754	6.7	63	709	4.3	54	626	−1.0	40	552	−7.1	30

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

[1] Army.
[2] Weather Bureau.
[3] Navy.
* Observations by radiometeorograph. Stations not so marked have observations by airplane.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during June 1938*

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (157 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (283 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Nashville, Tenn. (194 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	351	0.6	267	0.4	270	1.6	258	1.4	265	2.0	235	1.2	103	0.2	250	1.3	137	1.4	153	1.0	121	1.7	235	0.3	223	5.2
500	------	------	234	1.7	------	------	270	5.1	------	------	235	3.8	220	2.1	248	2.7	168	2.9	186	7.1	120	3.4	273	1.1	237	2.3
1,000	------	------	251	3.2	------	------	283	4.7	------	------	258	4.3	254	3.4	257	3.6	248	1.8	184	6.7	127	2.7	303	2.5	248	3.8
1,500	------	------	254	3.7	273	1.7	269	4.1	------	------	262	4.2	265	4.1	260	5.1	297	3.4	184	5.4	136	1.6	338	1.6	254	4.4
2,000	138	1.8	254	3.7	285	2.6	263	4.2	241	3.7	274	5.3	275	5.9	261	5.4	293	4.8	186	4.3	146	0.8	14	2.5	255	5.3
2,500	217	2.2	266	4.6	263	3.8	273	4.5	239	5.2	286	4.6	300	5.2	260	5.9	303	5.5	190	2.9	212	0.8	10	1.7	265	6.2
3,000	241	2.9	280	5.2	268	5.2	288	5.4	247	5.6	299	6.5	294	6.2	286	4.7	299	6.0	160	1.7	200	2.0	290	2.5	262	6.4
4,000	230	3.9	292	4.9	261	6.1	268	6.8	268	6.6	312	6.8	311	5.5	307	6.2	298	6.4	348	0.6	205	2.3	293	3.9	286	5.1
5,000	242	5.3	303	5.2	247	8.5	------	------	261	5.9	------	------	------	------	307	6.9	------	------	337	1.0	252	3.3	292	3.8	276	5.7

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during June 1938*—Continued

Altitude (meters) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii [1] (68 m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,292 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	331	1.1	256	2.0	152	2.0	161	1.9	------	------	328	1.2	238	0.8	152	2.2	233	1.1	254	0.5	149	1.4	83	1.4	271	0.4
500	308	4.2	238	2.7	167	4.3	187	4.7	------	------	282	2.2	261	2.5	------	------	204	0.5	295	2.6	12	1.3	------	------	321	2.8
1,000	308	3.8	314	5.5	200	7.5	213	5.6	------	------	268	2.6	286	3.0	------	------	344	0.6	272	4.4	24	1.4	217	0.5	319	3.1
1,500	296	4.1	323	3.9	219	5.6	235	5.1	------	------	271	3.6	282	3.2	137	1.9	------	------	271	5.1	348	1.4	266	1.3	316	3.5
2,000	287	3.9	322	4.0	244	4.0	259	5.6	------	------	281	3.9	283	4.2	170	1.3	------	------	261	6.4	291	1.8	252	2.3	302	2.9
2,500	304	3.2	318	3.5	273	4.5	276	5.8	------	------	288	5.0	287	4.9	206	1.8	------	------	271	6.6	265	2.0	250	2.6	280	4.0
3,000	315	2.5	299	2.0	289	3.7	279	6.7	------	------	296	4.3	284	5.6	244	3.1	------	------	292	5.6	251	3.4	252	4.0	306	7.9
4,000	37	3.7	293	4.7	316	3.3	292	6.4	------	------	304	3.5	328	6.7	252	5.9	------	------	306	6.4	------	------	257	5.4	296	5.2
5,000	------	------	248	6.8	------	------	------	------	------	------	------	------	347	5.4	244	9.1	------	------	295	5.5	------	------	263	6.9	------	------

[1] Navy stations.

TABLE 3.—*Maximum free-air wind velocities, (meters per second) for different sections of the United States based on pilot-balloon observations during June 1938*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast [1]	34.0	W	1,750	7	Buffalo, N. Y.	36.3	W	5,000	8	Cleveland, Ohio	36.8	W	5,200	8	Cleveland, Ohio.
East-Central [2]	26.4	SW	2,230	11	Cincinnati, Ohio	24.6	W	3,930	5	Richmond, Va.	40.0	WNW	11,070	8	Nashville, Tenn.
Southeast [3]	20.3	WSW	630	21	Jacksonville, Fla.	20.4	W	4,660	12	Spartanburg, S. C.	20.9	WSW	9,160	9	Spartanburg, S. C.
North-Central [4]	32.7	NW	1,870	1	Bismarck, N. Dak.	38.0	SW	2,630	7	Detroit, Mich.	31.5	WNW	8,110	8	Fargo, N. Dak.
Central [5]	36.0	W	1,960	6	Indianapolis, Ind.	30.8	WSW	3,690	10	Moline, Ill.	32.0	W	11,070	17	Moline, Ill.
South-Central [6]	33.1	S	1,710	10	Abilene, Tex.	27.6	W	4,070	26	New Orleans, La.	25.0	N	7,850	5	Houston, Tex.
Northwest [7]	29.9	W	2,500	8	Missoula, Mont.	37.0	W	4,720	8	Boise, Idaho	43.5	NNE	6,080	19	Medford, Oreg.
West-Central [8]	63.3	S	2,470	19	Modena, Utah	58.0	S	2,500	19	Modena, Utah	41.6	WSW	6,300	17	Reno, Nev.
Southwest [9]	27.3	NNW	1,990	13	Sandberg, Calif.	46.2	WSW	3,200	9	Winslow, Ariz.	40.8	W	11,660	16	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

Severe floods occurred during June 1938, principally in the Neosho, Smoky Hill, and Osage Rivers in Kansas. Excessively heavy local showers in Montana caused disastrous, sudden floods in that State with great property damage amounting to nearly $1,000,000 and the loss of about 58 lives, 48 of which were lost in the train wreck caused by a flood in Custer Creek, which flows into Yellowstone River about 30 miles below Miles City, Mont. High water in the San Joaquin and Columbia River basins caused considerable overflowing in those basins. A number of other floods, mostly of a minor character, also occurred with no damage of great consequence. Flood heights at all of the gaging points are shown in the accompanying table.

The following report on the floods in the Topeka, Kans., river district is submitted by the official in charge at that place:

Four overflows occurred in the Neosho River in Kansas during the month and the month preceding, one along the upper Smoky Hill, one along the Osage, one in the upper Solomon, and one in the Saline River. The first overflow of the Neosho was one that started in May and which began at Le Roy and Iola, Kans., on May 20 and by the 22d extended along the entire river below Emporia, Kans. This was preceded by a slight overflow at Le Roy on May 13 and at Iola and Chanute, Kans., on May 14. At Neosho Rapids and Le Roy the serious May overflow had subsided by May 26 and 29, respectively, but from Iola to the Oklahoma line it continued into June. At Oswego, Kans., where the crest was 23.5 feet, 6.5 feet above bankful, on June 1, the river did not return to its banks until June 6, making a total of 15 days for the overflow at that place. While crest stages did not approach previous records at any place, the duration of this overflow caused great damage to growing crops, estimated at $342,500, with 145,000 acres flooded. The total property loss was estimated at $410,350. One life was lost, though not directly due to the high water.

A slight overflow of the Neosho occurred at Le Roy on June 1 and at Iola on June 1 and 2 but caused little damage.

Another overflow of the Neosho occurred in Labette County, beginning June 17. This reached a crest of 24.0 feet, 2.0 feet above bankful, at Parsons, Kans., on the 17th and 21.8 feet, 4.8 feet above bankful, at Oswego on the 18th. Damage from this overflow totalled $28,000, being mostly to crops and livestock.

Heavy rains that totalled 5.33 inches at Council Grove, Kans., fell along the upper reaches of the Neosho River on June 10 and resulted in a disastrous overflow in that city and downstream to the junction of the Neosho with the Cottonwood River. Damage from this overflow was estimated at $314,806 the greater part of which was to property in Council Grove, and to growing crops. At Neosho Rapids, just below the mouth of the Cottonwood River, the highest stage measured was 22.8 feet, 0.8 foot above bankful, on the evening of the 12th, at which time the river was believed to

have fallen about 10 inches. No overflow occurred at Le Roy, the next gage below Neosho Rapids.

The overflow along the upper Smoky Hill was one of the greatest ever known in the vicinities of Ellsworth, Lindsborg, and Salina, Kans. This was due to torrential rains the closing days of May. At Ellsworth the crest was 27.2 feet, 7.2 feet above bankful, at 11 a. m. of June 1. The previous highest stage of record at Ellsworth was 25.75 feet, August 13, 1927. At Lindsborg the crest was 32.5, 11.5 feet above bankful, at 1:55 a. m. of June 3. This compares with 34.5 feet in the great overflow of 1903 at that place. At Mentor, Kans., a crest of 26.1 feet was reported at 11:30 a. m. of June 4, which compares with 26.5 feet in 1903. At Salina the crest was 23.23 feet, 3.23 feet above bankful, at 7 p. m. of June 5, which is the greatest at that place since the flood of 1903, when a crest stage of 24.6 feet occurred. This overflow extended only a comparatively short distance below Salina. At Enterprise, the first gage downstream, the river remained within its banks.

The total damage in Russell, Ellsworth, McPherson, and Saline Counties was estimated at $894,000, the greater part of which was to buildings, highways, and bridges, and to growing crops, of which latter more than 30,000 acres were flooded.

The overflow along the Osage River began June 11 in Osage County and was general to the Missouri line by the following morning. The crest at Ottawa was 29.0 feet, 5.0 feet above bankful, on June 13 and at La Cygne, 25.4 feet, 4.4 feet above bankful, two days later.

Damage from this overflow was estimated at $229,000, most of which was to matured and prospective crops of which latter 17,000 acres were flooded in Franklin and Linn Counties.

The State Highway Commission estimated damage to highways and bridges in Kansas due to heavy rains and overflows during the latter part of May and the fore part of June at from $250,000 to $350,000. This damage was widely scattered over the state.

A slight overflow of the upper Solomon River that lasted but one day occurred at Beloit, Kans., where the crest was 21.18 feet, 3.18 feet above bankful, on the 3d. Little or no damage resulted.

A slight overflow occurred in the Saline River, reaching a crest of 28.96 feet, 3.96 feet above bankful, at Tescott, Kans., on the 4th. No material damage resulted.

The official in charge at Miles City, Mont., reports as follows on the sudden flood in Custer Creek which caused the disastrous train wreck on the night of June 18–19th:

Custer Creek flows into the Yellowstone River about 30 miles below Miles City, Mont. Its general direction is from northwest to southeast. Most of the time it carries little or no water. It rises in a range of hills which forms part of the divide between the Missouri River and the Yellowstone River drainage basins. It drains approximately 162 square miles.

On the night of June 18th a severe rain storm, accompanied by light hail and light winds, formed at the head of this creek, later moving northeastward over Cherry Creek. It was plainly visible from Miles City but not a trace of rain fell there. Some observers report two storms, one about 4 p. m. and the other beginning about 9 p. m. Most reports agree that the greater portion of the rain fell between 9 p. m. and midnight. There were no authentic measurements made but from the contents of various containers exposed to the rain it was estimated that from four to seven inches of rain fell during this period.

The wreck of the Chicago, Milwaukee, St. Paul and Pacific Train No. 15 occurred at the bridge over Custer Creek a short distance from the Yellowstone River. The river was not high for this season, being about four feet below flood stage. Shortly after 10 p. m. of the 18th a train crossed the bridge safely, followed about 10:30 p. m. by a track walker. At that time water was flowing in the creek but was well within the banks and did not appear at all dangerous. It kept rising, however, and evidently weakened the bridge to such an extent that when Train No. 15 (The Olympian) came along about 12:40 a. m. of the 19th, it was not strong enough to support the locomotive which went down followed by 7 cars, 4 remaining on the track. The water was deep enough by this time so that one car, a tourist sleeper, was completely submerged.

The total loss of life was 48, with 64 persons injured.

Excessive rainfall in the form of a thunderstorm on the evening of June 22nd extended over all of the Bull Hook and Gravelly Coulee drainage basins in Hill and Blaine Counties. Rainfall was measured in this area as follows: Big Sandy, 3.68 inches; Harlem, 2.75 inches; North Montana Experiment Station, 1.12 inches; and Bearpaw Lease, 2.13 inches (on June 21). Bull Hook Creek, which runs through Havre, Mont., rose quickly to flood stage and inundated most of the city with water 2 to 3 feet deep. On the west slope of the Bearpaw mountains the water filled Gravelly Coulee and advanced with great force, taking a toll of nine lives and causing great property damage. The damage to property in Havre and immediate vicinity has been estimated at $270,000. Other damaging floods occurred in this vicinity in December 1896, April 1899, February 1916, December 1917, May 1927, and January 1935, but none were as destructive as this flood.

An overflow of the Kings River in California occurred from May 24 to June 12. An additional 9,400 acres were flooded in the Tulare Lake Basin, due to the breaking of the levees, increasing the Lake area to about 142,000 acres. The losses to prospective crops, machinery, and including expenditures on levee building are estimated at $10,000,000.

A report on the high water in the lower San Joaquin River during May and June by the official in charge, Sacramento, Calif., follows:

The snow depths in the Sierra Nevada Mountains at the end of the rainfall season, near the end of March, were greater than for many years past. This, together with the fact that the March rains left the streams high at the beginning of the spring melting season, accounts for the unusually high water during May. However, no flood stages were reached, except in the lower San Joaquin late in the month.

The flood stage of 17.0 feet was reached at Lathrop, Calif., on May 29, and the river continued to rise gradually as increasingly high temperatures rapidly melted the snow over the headwaters of the several eastern tributaries of the San Joaquin.

The crest at Lathrop was 20.4 feet on June 9th. This stage is not only the highest of record for any previous spring and summer snow-melting season, but with the exception of 22.5 feet in February 1911, and 20.9 feet on March 16, 1938, it stands as the highest for the entire period of record since the station was established in 1904.

There were 22 days when the river at Lathrop was above the 17-foot flood stage, establishing the longest flood period of record, except that of June 1911.

The June 1938 flood was practically a repetition of the conditions that occurred in March of this year. Nearly the same acreage was flooded. In the vicinity of the confluence of the Stanislaus and the San Joaquin rivers the previous breaks in the levees had not been repaired on account of anticipated high water with the melting of snow in the late spring.

As most of the crop damage had already been done in the March flood, the losses for the June period of high water were comparatively light, totaling about $100,000.

A violent thunderstorm, accompanied by intensive rainfall over a period of 20 minutes, on the afternoon of June 22, occurred in the vicinity of the village of Pilot Rock, Umatilla County, in northeastern Oregon. The excessive rainfall caused a wave of water 4 to 6 feet deep to overwhelm the village, resulting in damages estimated at $200,000. The cooperative observer measured 0.70 inch of rain during 5 minutes of the storm and estimated that 2.50 inches fell during the 20 minutes' duration of the storm. The rain gage was washed away during the flood.

The official in charge, Portland, Oreg., reports as follows on the annual rise in the Columbia River:

Average monthly temperatures for Idaho, Oregon, Washington east of the Cascades, and western Montana were above normal every month December to April, inclusive, except March when they were slightly below. Normal to above normal temperatures were also the rule for the Canadian portion of the Columbia drainage for the entire period. The weather was cool the first week in April, thereafter temperatures rose, the night readings being well above freezing in elevated sections for about 6 days. All reporting river stations began to show a substantial rise by April 10th, and no gaging station showed a lower stage until the crest of the summer rise was reached.

The precipitation by months, except for January, was mostly above average over the entire Columbia basin for the 7 months' period September 1st to March, inclusive. This was the heaviest seasonal amount for Oregon since 1893–94. The same situation

prevailed over most of the northwest, including western Montana and northwestern Wyoming. Average precipitation for Idaho as compared with the normal was as follows:

	Percent of normal
December	161
January	82
February	105
March	188
April	102

In March the precipitation for southwestern Idaho was 245% of the normal and for the southeast 222%. A similar condition occurred in Canada, only for different months. In the Monthly Weather Map for the Dominion of Canada for February 1938 a paragraph referring to precipitation contains the following statement: "moderate excesses above normal were generally reported while in the Okanagan, Kettle, and Kootenay valleys precipitation ranged from slightly above normal to more than three times the normal amount." In the same publication it is also noted that the excess in temperature above average in the Kettle and west Kootenay valleys ranged from 1 degree to 3 degrees while there was a negative departure for the east Kootenay and upper Columbia of from 2 degrees to 5 degrees.

Snow reports were secured from the following sources: The Water Rights Branch, Department of Public Lands, Victoria, B. C.; The Dominion Water Power Bureau, Vancouver, B. C.; The Bureau of Agricultural Engineers, Boise, Idaho, and Medford, Oreg.; and the Weather Bureau Offices, Boise, Cheyenne, Wyo.; Helena, Mont.; and Seattle, Wash.

Weekly snow reports from the Weather Bureau Offices at Boise, Helena, and Seattle, together with monthly tabulations from the first two stations, supplemented with reports from the offices of the Bureau of Agricultural Engineers, provided a frequent check on the snow situation as the season progressed. Reports from high elevations were very scarce.

High water caused considerable damage to crops and dykes in the Kootenai valley, while in the lower Columbia, flood waters resulted only in loss of pastures and prevented early planting of low lying fields. The total losses are estimated at more than $300,000.

Estimated flood losses by drainage basins during June 1938 are given in the following table:

Atlantic Slope drainage:	
Roanoke River	$99,000
Neuse River	26,000
Tar River	20,000
Upper Mississippi Basin:	
Chippewa River	27,000
Mississippi River	22,200
Missouri Basin:	
Rivers in Montana	1,000,000
Smoky Hill River	894,000
Republican River	13,000
Osage River (Kansas)	229,000
Arkansas Basin:	
Little Arkansas River	9,500
Neosho River	753,156
Pacific Slope drainage:*	
San Joaquin River	106,500
Columbia River	531,385
Total	3,730,741

*An estimated loss of $10,000,000 caused by the spring and summer overflow in the Tulare Lake Basin is not included.

The following report on the flood in the headwaters of the Mississippi River during May is submitted by the official in charge, Minneapolis, Minn., as follows:

The May 1938 flood in the extreme upper Mississippi River was the result of a prolonged period of heavy rains that began on April 14 and continued almost daily until May 13.

There is a total of 26 rain gaging stations in the drainage area above Minneapolis, which measures 19,680 square miles, and the average catch of these rain gages for the entire 30-day period was 8.10 inches. As this portion of the Mississippi River is a prairie and woodland stream with low banks and of only moderate width, vast areas of low lands along the main stream are inundated in floods. On the first of May the river was well within its banks, but the continued rains raised the stages above the flood limits on May 6 at Aitken and Fort Ripley, Minn., the two upper gaging stations.

The river crested at Aitken on May 12, with a stage of 15.7 feet, 3.7 feet above flood stage, and at Fort Ripley on May 11 with a stage of 10.8 feet, 0.8 foot above flood stage, as shown in the table below. Flood stage was not reached at Minneapolis or St. Paul; the crest at the former place being 15.0 feet on May 12 and 13, flood stage 16 feet; and at the latter place the crest was 11.2 feet on May 14, flood stage 14 feet.

Table of Flood Stages in Upper Mississippi River During May 1938

Station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
Aitken, Minn.*	12	6	28	15.7	12
Fort Ripley, Minn.	10	9	19	10.8	11
Minneapolis, Minn.	16	----------	----------	15.0	12, 13
St. Paul, Minn.*	14	----------	----------	11.2	14

*Records from U. S. Engineer Office.

Crop losses, confined principally to meadows and hay lands, are placed at $55,000. The major damage was to highways with losses estimated at $1,000,000.

Table of flood stages during June 1938

[All dates in June, unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ST. LAWRENCE DRAINAGE					
Lake Erie					
Maumee: Fort Wayne, Ind.	Feet 15	27	27	Feet 15.2	27
ATLANTIC SLOPE DRAINAGE					
Schuylkill: Reading, Pa.	7	28	28	7.1	28
James: Columbia, Va.	10	20	[1] 24	14.8	21
Roanoke:					
Randolph, Va.	21	21	24	25.2	23
Weldon, N. C.	31	21	26	39.9	24
		29	[2]	31.7	30
Williamston, N. C.	10	24	[2]	12.5	29
Tar:					
Rocky Mount, N. C.	8	21	26	10.5	25
Tarboro, N. C.	18	25	28	19.5	27
Greenville, N. C.	13	24	[2]	15.3	29
Neuse:					
Neuse, N. C.	14	21	26	17.6	25
Smithfield, N. C.	13	20	28	16.3	27
Goldsboro, N. C.	14	24	[2]	[3]	----------
Kinston, N. C.	14	30	[2]	[3]	----------
Santee: Rimini, S. C.	12	5	5	12.0	5
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Chippewa: Durand, Wis.	11	2	5	12.5	3
Rock: Moline, Ill.	10	26	28	10.3	27
Skunk: Augusta, Iowa	15	15	16	17.0	16
Bourbeuse: Union, Mo.	12	11	14	20.2	13
Meramec:					
Pacific, Mo.	11	11	15	19.7	12
Valley Park, Mo.	14	11	15	23.9	12
Mississippi:					
Keokuk, Iowa	12	1	9	13.0	3
		15	17	13.2	16
Quincy, Ill.	14	2	10	15.0	4, 7, 8
		15	18	14.9	17
Hannibal, Mo.	13	May 20	20	15.0	7, 8
Louisiana, Mo.	12	May 22	20	13.7	9
Missouri Basin					
Solomon: Beloit, Kans.	18	2	3	21.2	3
Smoky Hill:					
Ellsworth, Kans.	20	1	2	27.2	1
Lindsborg, Kans.	21	1	5	32.5	3
Salina, Kans.	20	4	7	23.2	5
Osage:					
LaCygne, Kans.	21	12	18	25.4	15
Ottawa, Kans.	24	12	14	29.0	13
Osceola, Mo.	20	May 25	3	24.9	May 30
Missouri: St. Charles, Mo.	25	12	12	25.4	12
Ohio Basin					
West Fork of White:					
Anderson, Ind.	10	26	29	13.7	27
Noblesville, Ind.	14	28	28	14.8	28
Elliston, Ind.	18	29	29	18.0	29
Edwardsport, Ind.	12	2	6	13.5	5
		28	[2]	15.2	July 1
Wabash:					
Wabash, Ind.	12	26	30	16.9	27
LaFayette, Ind.	11	26	[2]	18.9	29
Covington, Ind.	16	28	[3]	21.5	30
Terre Haute, Ind.	14	30	[3]	[3]	----------
Ohio: Cairo, Ill.	40	May 29	3	41.2	May 31-1

[1] Fell slightly below flood stage on the 22d.
[2] Continued at end of month.
[3] Crest not reached.

Table of flood stages during June 1938—Continued

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI SYSTEM—continued					
White Basin					
White:	*Feet*			*Feet*	
Georgetown, Ark.	21	May 28	8	22.7	1
Clarendon, Ark.	26	2	13	27.0	7, 8, 9
Arkansas Basin					
Little Arkansas: Sedgwick, Kans.	18	25	26	23.8	25
Cimarron: Perkins, Okla.	11	1	1	11.2	1
		11	11	11.0	11
		21	21	11.1	21
Neosho:					
Neosho Rapids, Kans.	22	12	13	22.8	12
LeRoy, Kans.	23	May 31	1	25.3	1
Iola, Kans.	15	May 20	2	20.5	May 24
Oswego Kans.	17	May 22	5	23.5	1
		7	9	20.8	9
		16	19	21.8	18
North Canadian: Yukon, Okla.	8	May 19	29	12.6	May 22
				11.2	4
				10.1	21
Arkansas:					
Fort Smith, Ark.	22	13	13	22.0	13
Van Buren, Ark.	22	13	13	22.3	13
Red Basin					
Sulphur:					
Ringo Crossing, Tex.	20	8	13	28.0	9
Naples, Tex.	22	12	19	25.6	14
WEST GULF OF MEXICO DRAINAGE					
Brazos: Waco, Tex.	27	17	17	27.5	17

Table of flood stages during June 1938—Continued

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
GULF OF CALIFORNIA DRAINAGE					
Colorado Basin	*Feet*			*Feet*	
Eagle: Eagle, Colo.	5	May 29	10	5.9	6
		13	15	5.2	14
		21	24	5.3	22, 23
Roaring Fork: Carbondale, Colo.	5	May 28	(1)	6.2	May 30
				6.7	6
				6.5	13
				6.3	23
Gunnison: Delta, Colo.	9	May 27	9	11.2	May 30
		13	14	10.8	4, 5
		21	24	9.7	14
				9.7	22
Colorado: Grand Junction, Colo.	11	4	8	11.3	5-7
PACIFIC SLOPE DRAINAGE					
San Joaquin Basin					
Kings: Piedra, Calif.	10	May 24	12	13.2	4
San Joaquin: Lathrop, Calif.	17	May 29	16	20.4	7, 9
		19	21	17.2	20, 21
Columbia Basin					
Kootenai: Bonners Ferry, Idaho	31	May 29	1	31.5	May 30
Clearwater: Kamiah, Idaho	12	May 25	4	14.6	May 29
		6	6	12.0	6
Willamette: Portland, Oreg.	18	May 29	16	20.8	1-2, 9-11
Columbia: Vancouver, Wash.	15	May 26	(1)	21.5	10

[1] Continued at end of month.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL in charge]

NORTH ATLANTIC OCEAN, JUNE 1938

By H. C. HUNTER

Atmospheric pressure.—The pressure averaged slightly to moderately higher than normal over nearly all of the North Atlantic, but from the vicinity of the Azores northward and northeastward it was lower than normal. The greatest station departure of the month was 0.14 inch below normal at Reykjavik, Iceland. The first 8 days and the period from the 19th to the end of June were marked by low pressure most of the time from Icelandic waters to the region around the British Isles.

The highest vessel pressure reading yet found is 30.63 inches, during the forenoon of the 10th, noted on the American steamship *Edward L. Doheny*, near latitude 50° north, longitude 23° west. The lowest vessel reading is from the wireless report of an unidentified vessel near the Orkney Islands, just before noon of the 29th, 28.94 inches. However, for the 28th and the latter part of the 27th no vessel reports are at hand from the vicinity of the Orkney and Shetland groups, and table 1 shows a reading lower by more than a quarter of an inch at Lerwick on the 28th.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, June 1938*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.77	−0.09	30.06	29	29.32	3
Reykjavik, Iceland	29.74	−.14	30.15	14	29.32	28
Lerwick, Shetland Islands	29.74	−.06	30.18	17	28.67	28
Valencia, Ireland	30.00	.00	30.48	13	29.18	28
Lisbon, Portugal	30.09	+.06	30.27	9	29.86	7
Madeira	30.13	+.06	30.27	9	29.90	24
Horta, Azores	30.23	−.01	30.44	27	30.00	15
Belle Isle, Newfoundland	29.93	+.07	30.34	17	29.40	22
Halifax, Nova Scotia	29.99	+.02	30.32	11	29.74	6, 26
Nantucket	29.99	+.01	30.40	10	29.80	5
Hatteras	30.03	+.02	30.30	10	29.84	22
Bermuda	30.20	+.07	30.34	10, 11	29.84	2
Turks Island	30.05	+.02	30.11	27, 28	29.97	1, 2, 14, 15
Key West	30.03	+.04	30.13	10	29.87	3
New Orleans	30.03	+.05	30.21	12	29.85	2

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—June normally is one of the quietest months on the North Atlantic, but this year it was less quiet than usual, and there was marked contrast with the especially placid June of 1937.

As the month opened a storm of considerable strength had developed over the Grand Banks; it advanced for a day or more slowly toward the east-northeastward, then turned more to northward, as high pressure moved in behind it. Several vessels met fresh to strong gales during these early days of June from the vicinity of the Grand Banks eastward to beyond mid-ocean.

The fortnight from the 4th to 17th furnished almost no gale reports. During much of this period pressure was a little higher than normal over the region of Bermuda and to the eastward. Trade winds to the southward and southwestward were somewhat intensified, and two instances were reported from the Caribbean—one near the western end and one near the eastern—of winds attaining force 8.

About the 17th a belt of low pressure became established nearly along the 60th parallel of latitude, extending from the vicinity of Norway to or beyond northern Hudson Bay. Within this belt some LOWS were well marked for a few days, especially one which was near the southern tip of Greenland on the 17th and thereafter moved slowly eastward. From the 18th to the 21st some vessels on northern routes, when near or to northward of the 55th parallel and to eastward of the 35th meridian, noted strong to whole gales; the Belgian motorship *Lubrafol* recorded force 11, the only reported instance of such force this month over Atlantic waters. About the 22d there was a weakening of the low pressure centers over the ocean and no further gales in connection with them are of record.

On the 26th a center of low pressure appeared between Ireland and southern Greenland and gained force rapidly, moving toward the east-northeast. There were four reports of whole or strong gales on the 28th over waters to the southwestward of Ireland.

Just afterward there occurred the only noteworthy June storm activity close to the eastern United States coast. A less energetic LOW than the one that had just passed the British Isles, moved slowly eastward off the middle and north Atlantic coast, but was vigorous enough to cause strong gales southeast of New England on the 30th. This LOW soon turned northward till it was once more over the land.

Fog.—Fog was plentiful from near Delaware Bay northeastward and eastward to the southern part of the Grand Banks area and on to about the 35th meridian. Nearly throughout this stretch the occurrence was greater than usual in June, and in the 5° square, 40° to 45° North, 65° to 70° West, there were no less than 25 days with fog, every day from the 15th to the 29th inclusive furnishing reports. Near the tail of the Grand Banks the square 40° to 45° N., 45° to 50° W. had fog on 19 days. For a moderate distance to southeastward of Nova Scotia and for a greater distance directly to eastward of Newfoundland, including the northern portion of the Grand Banks, fog was somewhat less prevalent than normally in June, and the period from 8th to 19th inclusive embraced a very large part of the fog reports from these regions.

Between the 35th and the 15th meridians, fog was almost completely absent to southward of 45° N., while to northward it was less frequent than usual in June. However, between the 15th and 5th meridians, in the latitude of the Bay of Biscay and the western end of the English Channel fog was noted as more prevalent than usual with nearly all of it during the period from the 14th to the 26th.

OCEAN GALES AND STORMS, JUNE 1938

Vessel	Voyage		Position at time of lowest barometer		Gale began June—	Time of lowest barometer June—	Gale ended June—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Black Hawk, Am. S. S.	Antwerp	New York	44 27 N.	46 10 W.	1	4p, 1	2	29.05	ESE.	SW, 7	NNW.	NW, 9	SSW-WNW.
American Importer, Am. S. S.	Belfast	Boston	45 20 N.	42 10 W.	1	9p, 1	2	29.10	SE.	SW, 9	WNW	SW, 9	SW-WSW.
Pres. Harding, Am. S. S.	Cobh	New York	44 30 N.	41 34 W.	1	10p, 1	2	29.09	SSE.	SW, 9	SW.	WSW, 9	SSW-NW.
American Banker, Am. S. S.	London	Boston	45 30 N.	36 30 W.	1	11p, 1	2	29.32	S.	SW, 9	WSW.	SW, 9	SW-W.
City of Hamburg, Am. S. S.	Norfolk	Havre	43 42 N.	39 39 W.	1	Mdt, 1	2	29.44	SW.	SW, 9	W.	WSW, 9	SW-WSW.
Boschdyk, Du. S. S.	New Orleans	London	[1]43 09 N.	36 03 W.	2	4a, 2	2	29.62	SW.	SW, 8	NW.	WSW, 8	SW-W.
Winkler, Pan. M. S.	Birkenhead	Philadelphia	48 04 N.	27 27 W.	2	Noon, 2	3	29.32	SW.	SSW, 7	WNW.	SSW, 8	SSW-WNW.
Spaarndam, Du. S. S.	Rotterdam	New York	47 01 N.	30 34 W.	1	Noon, 2	3	29.39	SW.	SW, 8	WNW.	SW, 8	S-NW.
Sarcoxie, Am. S. S.	Havre	do.	49 00 N.	27 40 W.	2	4p, 2	3	29.33	S.	SSW, 7	WNW.	NW, 8	SSW-WNW.
Sangstad, Nor. M. S.	Leith	Savannah	57 14 N.	25 55 W.	2	7a, 3	4	[2]29.05	S.	SW, 8	SE.	W, 8	S-W-SE.
Cefalu, Hond. S. S.	Havana	Cristobal	9 30 N.	80 00 W.	5	7a, 7	6	29.86	E.	SE, 3	E.	E. 8	NE-SE.
Tynefield, Br. M. S.	Newcastle	Las Piedras	13 16 N.	67 47 W.	13	7a, 14	14	29.91	ESE.	ESE, 6	ESE.	ESE, 8	SSE-ESE.
Mormacsun, Am. S. S.	Viborg	Philadelphia	54 08 N.	32 08 W.	18	5a, 18	18	29.70	NW.	NW, 7	W.	NW, 9	WSW-NW.
Svanhild, Dan. S. S.	New York	Copenhagen	55 20 N.	25 15 W.	18	8p, 18	19	[2]29.70	W.	W, 9	W.	W, 9	
Scanyork, Am. S. S.	Copenhagen	New York	56 30 N.	18 18 W.	20	4p, 20	21	29.42	S.	WSW.	WNW.	WSW, 9	S-WSW.
Lubrafol, Belg. M. S.	Gothenburg	Corpus Christi	[1]58 40 N.	14 42 W.	20	4a, 21	21	29.12	WSW.	SW, 10	WNW.	WNW, 11	SW-W.
Svanhild, Dan. S. S.	New York	Copenhagen	59 26 N.	8 45 W.	21	10a, 21	22	[2]29.21	SW.	SSW, 9	W.	SSW, 10	
Chattanooga City, Am. S. S.	Avonmouth	Portland, Maine.	51 30 N.	22 31 W.	27	4a, 28	28	29.14	SSW.	WSW, 10	NW.	WSW, 10	SW-WNW.
Boston City, Br. S. S.	Swansea	Montreal	52 30 N.	18 20 W.	28	8a, 28	28	29.03	SSW.	S, 9	NW.	W, 10	S-NW.
Black Eagle, Am. S. S.	Antwerp	New York	49 30 N.	13 00 W.	28	11a, 28	28	29.50	WSW.	WSW, 8	WNW.	WSW, 9	
Pipestone County, Am. S. S.	Havre	do.	49 42 N.	15 30 W.	28	11a, 28	28	29.53	W.	W, 8	WNW.	WNW, 9	W-WNW.
Collamer, Am. S. S.	Bordeaux	do.	40 48 N.	65 10 W.	29	1a, 30	30	29.71	SSW.	S, 9	NNW.	S, 9	S-NNW.
Padnsay, Am. S. S.	St. Vincent, C. V. I.	Boston	41 14 N.	64 16 W.	29	2a, 30	30	29.69	SSW.	SW, 9	NE.	SW, 9	S-NW.
NORTH PACIFIC OCEAN													
R. J. Hanna, Am. S. S.	Los Angeles	Balboa	[1]14 38 N.	95 42 W.	2	4a, 2	2	29.81	NE.	NE, 7	NE.	NE, 8	
Hamakua, Am. S. S.	Hilo	San Francisco	37 18 N.	124 18 W.	2	3p, 2	2	29.96		NW, 5		NW, 8	
Honolulan, Am. S. S.	San Francisco	Portland, Oreg.	41 42 N.	124 30 W.	3	4a, 3	3	29.95	NNW.	NNW, 7	NNW.	NNW, 8	
Toorak, Br. S. S.	Shanghai	Los Angeles	36 00 N.	123 48 W.	8	4a, 9	8	29.87		NW, 7		N, 8	N-NW.
Pres. Cleveland, Am. S. S.	Honolulu	San Francisco	37 41 N.	123 00 W.	8	4a, 9	8	29.73	N.	NNW, 6	NNW.	NNW, 8	
Solana, Am. S. S.	Manila	do.	[1]37 52 N.	122 24 W.	8	4a, 10	9	29.84	N.	SW, 3	NW.	NNW, 8	NW-SW.
Makiki, Am. S. S.	Hilo	do.	[1]37 39 N.	122 56 W.	8	8a, 10	10	29.92	NW.	NW, 6	NW.	N, 8	
Chickasaw City, Am. S. S.	do.	Balboa	17 30 N.	125 42 W.	15	5p, 15	15	28.84	NNE.	ESE, 5	S.	NNE, 11	NNE-ESE-S.
Nako Maru, Jap. M. S.	Yokohama	Los Angeles	46 12 N.	168 48 W.	17	Noon, 17	18	29.48	W.	W, 8	WSW.	W, 9	W-SW.
Honolulan, Am. S. S.	Los Angeles	Balboa	21 10 N.	107 55 W.	22	7a, 22	22	29.59	E.	SE, 8	SSE.	SE, 8	ESE-SSE.
Helen Whittier, Am. S. S.	do.	do.	[1]15 47 N.	98 55 W.	25	12½p, 26	26	29.14	E.	Lt. var.	SSW.	SW, 11	NE-calm-WSW-SW.
Bengalen, Du. M. S.	Manila	Portland, Oreg.	30 00 N.	135 50 E.	29	2a, 29	30	29.36	SSE.	SE, 4	SSW.	SSW, 10	E-SE.

[1] Position approximate.

[2] Barometer uncorrected.

NORTH PACIFIC OCEAN, JUNE 1938

By WILLIS E. HURD

Atmospheric pressure.—Early summer usually witnesses a marked weakening to almost complete disappearance of the Aleutian cyclone. In June 1938, however, pressure over the eastern Aleutians was extraordinarily low for the month, the average barometer at Dutch Harbor, 29.68, being 0.22 inch below the normal. June was the fourth successive month in which the Aleutian LOW was unusually developed.

Anticyclones prevailed over most central waters of the ocean and thence northeastward to the coast between Oregon and Southeastern Alaska. Average pressures at Midway Island and Tatoosh Island, at the center and the eastern edge, respectively, of the North Pacific HIGH were above the normal of the month.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, June 1938, at selected stations*

	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	29.89	−0.10	30.18	6	29.18	19
Dutch Harbor	29.68	−.22	30.20	2	29.00	17
St. Paul	29.75	−.11	30.32	2	29.20	17
Kodiak	29.81	−.10	30.34	22	28.86	18
Juneau	30.01	.00	30.36	21	29.39	18
Tatoosh Island	30.09	+.07	30.36	2	29.90	23
San Francisco	29.91	−.05	30.10	13	29.71	28
Mazatlan	29.85	+.02	29.94	30	29.74	27
Honolulu	30.03	−.01	30.13	6	29.94	1
Midway Island	30.14	+.09	30.30	18	30.00	30
Guam	29.84	−.03	29.89	5	29.77	27
Manila	29.78	+.03	29.86	5–10	29.62	30
Hong Kong	29.71	+.01	29.86	6	29.51	29
Petropavlosk	29.85	----------	30.18	18	29.53	10

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Storms and gales of the extratropics.—Although numerous depressions occurred in northern and extreme northwestern waters of the North Pacific, only one was of more than moderate depth. This prevailed over the eastern Aleutians and the Gulf of Alaska on the 16th to 18th and gave the lowest pressure reading of the month, 28.86, at Dutch Harbor on the 18th. It also caused the strongest wind reported for the month in upper latitudes, a gale of force 9, experienced by the Japanese motorship *Nako Maru*, near latitude 46° N., longitude 169° W., on the 17th. Local winds of force 8 occurred in the vicinity of the Gulf on the 18th and near the tip of the Alaska Peninsula on the 21st. No gales were reported during June from ships in high latitudes to the westward of the 180th meridian.

On the 2d and 3d and again on the 8th and 9th several vessels reported northwesterly gales close off the California coast. The eastern slope of a strong oceanic cyclone lay along the coast on these days, while LOWS lay over central California. The results were steep pressure gradients and strong winds along a narrow strip of sea between about Cape Mendocino and Point Conception.

Tropical cyclones and gales.—At least three distinct cyclonic developments occurred over extreme southeastern waters of the North Pacific this month. Two were of near hurricane intensity as observed over short periods. In addition, there was another possible development, shown only by an observation of a northeast gale of force 8 experienced by the American steamer *R. J. Hanna* south of the Gulf of Tehuantepec on the 2d.

The earliest and deepest of the known cyclones was observed on the 15th by the American steamer *Chickasaw City*, Capt. H. G. Eaton, observer J. Van Duren, Hilo toward the Canal Zone. The ship entered the storm zone with a northeast wind of force 7 at 4 a. m., when about midway on her voyage. Shortly after noon the gale had increased to force 10, and at 4 p. m. was of force 11. At 5 p. m. the ship's barometer, corrected, read 28.84, with wind changing from strong northeasterly to east-southeast, force 5, at or near the storm center. Southeast to south winds of forces 8–10 continued thereafter until midnight. The cyclone was apparently moving in a northwesterly direction. There are no further observations available concerning its movements.

On June 20 there were evidences of a cyclonic formation west of Manzanillo, Mexico. On the Dutch motorship *Loosdrecht* the barometer fell to 29.68 inches near 19° N., 105½° W., with a west wind of force 6. The ship reported receiving radio warnings of a storm in the vicinity. No further developments were observed on the 21st, but on the 22d, at the entrance to the Gulf of California, the American steamers *Honolulan* and *Kentuckian* reported gales of fresh to strong force, one from southeast, the other from southwest, with lowest barometer 29.59 inches. This depression was not observed thereafter.

A further near-hurricane was experienced by the Matson Line steamer *Helen Whittier* off the Mexican coast southeast of Acapulco. This ship, Los Angeles to Balboa, according to a special report made to the Hydrographic Office by Second Officer R. H. Ritter, first came under the influence of the cyclone at 1 p. m. of the 25th, with increasing east winds and slowly falling barometer. At noon of the 26th, after northeast winds of force 10 with heavy rain, the storm suddenly abated as the ship entered the center of the storm in 15°55′ N., 99°05′ W., by dead reckoning. Here the winds were calm to light and variable for an hour, lowest barometer 29.14. At 2 p. m. the wind was west-southwest, force 10, and at 3 p. m., southwest, force 11, thereafter rapidly decreasing. Mr. Ritter said the storm appeared to be traveling on a northwesterly course.

Elsewhere in this issue of the REVIEW is a report by the Rev. Bernard F. Doucette, S. J., Philippine Weather Bureau, of two typhoons that occurred in the Far East during June 1938. In connection with these storms, D. C. Mens, observing officer on the Dutch motorship *Bengalen*, Manila toward Portland, reported on June 26, when near 22° N., 124° E., that the ship's barometer was falling due to the presence of a typhoon east of Luzon. Typhoon indications continued to be observed on ship, but no gales were encountered until the 29th when, near 30° N., 136° E., the vessel ran into southeasterly winds of force 8, lowest barometer 29.36. At local noon of the following day, in 33°30′ N., 143°14′ E., the gale had risen to force 10 from the south-southwest. By 4 p. m. the wind had fallen to force 8, as the typhoon moved northward toward Japan.

Fog.—There was no material change in fogginess during June over that observed the previous month on the North Pacific, except that along the western part of the northern routes there was some increase in frequency. From near the central Aleutians southwestward to northern Japan fog occurred on about 20 to 30 percent or more of the days. To the eastward of this belt of major occurrence the frequency decreased to about 3 to 15 percent. In east longitudes fog was observed infrequently as far south as the 30th parallel. Fog was reported on 4 days off the Washington coast; on 4 days off southern California; and on 2 days off Lower California.

St. Elmo's fire.—The British steamship *Jhelum* reported to the Hydrographic Office that, during a heavy shower in the Gulf of Tehuantepec and for a half hour

thereafter on June 19, purple glows were observed on the mastheads and aerials.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST, JUNE 1938

BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Typhoons of June 22–27 and June 25–July 1, 1938.—The pressure values reported over the Philippines were very high during the first two-thirds of the month and began to fall on June 20, after which there were signs that a low pressure area was in existence between the Archipelago and the Mariana Islands. Not until June 22, however, did a definite center manifest itself, appearing about 500 miles east-northeast of Manila. Moving about 250 miles along a west-northwesterly course and then changing to a northerly one, the disturbance, on the morning of June 24, reached the extreme eastern section of the Balintang Channel, where it was powerful enough to be classified as a typhoon. A sudden change of direction to the east followed, and then, during the afternoon hours of June 25, a shift to the northeast brought the typhoon to the regions half way between the northern Nansei Islands and the Bonins, where the storm disappeared.

While the storm described above was intensifying, another weak center appeared west of the Mariana Islands. It moved along a west-northwesterly track to the locality of latitude 20° N., longitude 130° E., where it intensified as it changed its direction to the north-northeast (morning hours of June 27). During the next few days the storm moved toward Japan, being central about 100 miles southeast of the coastline on June 30, 6 a. m. (Manila time). A change to the east-northeast kept the center from passing over land, and then an inclination to the northeast combined with a more rapid movement carried the disturbance on toward the Aleutian Islands.

Both of the above typhoons were well developed. After June 25, when the centers were more than 200 miles away from northern portions of the Archipelago, pressure values between 749.5 mm. and 752 mm (29.508 in. and 29.606 in.) were maintained for four or five days. On June 29, Oshima and Naha, Nansei Islands, had values of 748 mm and 749 mm (29.449 in. and 29.488 in.) as the typhoon passed to the east.

On June 29 and 30, great destruction resulted in Japan, according to news dispatches. About 100 lives were lost, many more persons were missing, and thousands of houses were destroyed. Railroads suffered much damage, tracks being washed away by the floods and landslides. In the Philippines, rainy weather prevailed during this period, causing the loss of three lives and considerable flood damage.

Connected with a description of these two typhoons, a few remarks concerning the air streams surrounding the centers might be of interest. On June 20 the front between the southwest monsoon air (Te) and the trade wind air (Tm), which had been quasi-stationary over the southern part of the China Sea, moved in a northeasterly direction across the Philippines and relocated itself over the Pacific, extending from the Continent across the locality of the Balintang Channel and over the Pacific to the northern part of the Mariana Islands. The two typhoons developed along this front; the first at the western part; the second over the eastern portion. The upper wind data available indicate that the southwest monsoon air was an important factor in the development of the two typhoons. During the whole period, there was a steady southwest-quadrant current over the Straits Settlements, Siam, Indochina, Hong Kong, and the Philippines. Velocities reported on June 20 were under 40 k. p. h. and afterwards they steadily increased to values between 50 and 70 k. p. h. (these velocities occurring on June 27 to 29). Then they gradually weakened as the second typhoon approached Japan. Other air streams moving toward the storm centers did not equal these velocities. At Guam, with southwesterly winds changing to southeasterly, velocities did not rise above 45 k. p. h. The U. S. S. *Ramapo* was able to give information northeast of the center and reported weak southeast winds. At Shanghai, (west-northwest and west of the typhoon) the U. S. S. *Augusta* has southwesterly winds until June 27 when they changed to southeast quadrant, velocities always under 45 k. p. h. These upper air observations were made (except in the case of Guam) much closer to the center than Siam or Indochina, at which places much stronger winds were reported.

Another interesting air stream to be noted is an easterly current aloft over the northern part of the Philippines and Indochina, this current flowing above the southwesterly winds. At Aparri, a station in northern Luzon, the southwesterly current varied in thickness from 1700 *m* to 3700 *m* with easterly winds above it. At Manila, the easterly movement of the high clouds showed the existence of this current but only one balloon ascent (that of June 25, afternoon) reached the easterly current, altitude 4400 *m*. Over Indochina, the easterly current, according to the pilots available, was never below 6500 *m*. At Hong Kong, likewise, the easterly winds were high, 5000 *m* or 6000 *m*. These few remarks are given to show the existence of that air stream above the more active, as shown by velocities, southwesterly current at the lower levels.

SEA SURFACE TEMPERATURE SUMMARY FOR THE VICINITY OF THE GRAND BANKS, 1912–31

By GILES SLOCUM

The area embraced in this summary comprises nine 1° squares, namely: From 45° North to 46° North, 50° West to 55° West; from 46° North to 48° North, 50° West to 52° West.

This area lies to the south and east of Newfoundland, and is within the Labrador Current. The surface water in this region is colder than in any part of the North Atlantic Ocean farther eastward at the same or lower latitudes. It is not as cold as the surface water of the Gulf of St. Lawrence, or that of the North Pacific Ocean at the same latitude in the vicinity of Hokkaido and Chishima. It is colder than the surface water of the Sea of Okotschk and the northern part of the Gulf of Tartary in summer, but is warmer in winter; and it is colder in winter [1] than the cold surface water of the polar

[1] Winter and summer refer to the cold and warm seasons, respectively, of the hemisphere concerned.

current in the South Atlantic Ocean east of Patagonia, and warmer in summer.

This portion of the Labrador Current is therefore not a uniquely cold body of water, latitude considered, although it is an example of water having a rather extreme negative temperature anomaly as compared with the normal surface temperature for the latitude. It may be classed as a typical east coast cold current, such as is found in middle latitudes in all three cases where a continent extends poleward beyond 45° latitude.

During the winter, the water in the area is often partially frozen at the surface, and is therefore perilous for navigation. For this reason, sea traffic is very seasonal, and few observations are made in February, March, or April. Because of the dearth of observations during these months, it has not been possible to compute monthly mean temperatures for the area which are significant beyond integral values (°F.) for these 3 months. Similarly, as the table shows, under the caption, "Total Number of Observations", there have been too few observations during all months of the 8 years, 1916 to 1923, inclusive, to make monthly mean temperature values that justify closer approximation than to whole degrees. There are 16 gaps in the table, representing months with no extant observations of sea-temperature. For all months outside these three categories, temperatures have been computed to tenths of a degree.

This is the eleventh of a series of temperature history tabulations of this character, showing sea-surface temperatures for small areas in American and western North Atlantic waters. The first of the series appeared in the November 1934 issue of the MONTHLY WEATHER REVIEW, and the last previous tabulation appeared in the December 1937 issue.[2]

Monthly and annual mean sea-surface temperatures at the Grand Banks, 1912 to 1931, inclusive

Year	Total number of observations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual[1]
1912	321	33.2	30	28	32	34.5	40.4	46.2	51.0	52.2	45.8	42.3	37.2	39.4
1913	293	33.9	30	34	36	36.1	40.1	44.8	54.2	55.2	54.5	43.4	39.6	41.8
1914	234	35.3	28	40	34	35.7	38.0	46.1	51.9	52.5	46.8	42.5	36.5	40.5
1915	210	32.5	31	30	30	34.4	41.1	46.1	51.3	52.0	48.4	40.3	39.0	39.7
1916	129	32	32	31	32	38	47	53	55	55	49	41	39	42.1
1917	61	36	(2)	32	(2)	34	46	54	63	56	52	(2)	41	44.0
1918	13	(2)	(2)	32	(2)	32	43	(2)	(2)	52	52	39	36	40.5
1919	90	34	31	31	32	36	38	48	53	57	51	39	37	40.5
1920	97	34	33	(2)	33	38	41	50	60	54	52	41	36	42.1
1921	102	34	(2)	44	36	34	42	50	57	54	48	41	36	42.4
1922	97	34	36	37	32	35	41	51	57	59	50	42	35	42.3
1923	97	32	(2)	(2)	27	38	41	43	52	54	51	49	41	41.1
1924	157	35.5	35	(2)	35	39.1	41.8	53.1	59.4	58.7	51.5	42.2	41.3	44.1
1925	160	34.4	34	35	34	36.9	40.0	55.9	59.0	55.4	47.5	39.1	36.5	42.3
1926	151	33.8	32	32	32	36.3	40.2	46.3	55.2	54.6	51.3	44.6	42.1	41.7
1927	159	38.8	32	36	36	36.4	41.2	54.0	60.7	54.8	52.1	(2)	41.2	43.9
1928	187	34.9	31	33	(2)	35.4	42.6	55.8	56.4	57.5	50.1	(2)	42.1	43.0
1929	184	34.3	33	34	30	35.5	41.6	47.5	59.4	54.0	51.5	44.6	37.7	41.8
1930	173	33.7	32	38	32	37.2	42.8	55.5	56.6	55.5	50.5	41.5	37.8	42.8
1931	195	37.2	35	36	39	39.3	43.9	58.1	59.2	57.7	51.7	44.7	36.1	44.8
Number of years of record		19	16	17	17	20	20	19	19	20	20	17	20	20
Mean (1912–31)[1]		34.4	32.1	34.3	33.0	36.1	41.7	50.5	56.4	55.1	50.4	42.2	38.4	42.0

[1] Means were computed, using interpolated values for missing months. All monthly means were carried to one decimal place when computing annual and period means, which latter are, therefore, not exact means of figures given in the body of the table.

[2] No data.

[3] The statement in the December 1937 issue, that the tabulation in that number was the ninth of the series, is in error. It was the tenth.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, June 1938*

[For description of tables and charts, see REVIEW, January, p. 29]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	77.5	−0.8	3 stations	98	[1] 11	St. Bernard	50	29	4.55	+0.35	Valley Head	10.50	Monroeville	1.32
Arizona	75.1	−.3	do	116	[1] 5	Fort Valley	26	[1] 13	.88	+.53	Helvitia	3.04	5 stations	.00
Arkansas	75.8	−1.4	Hot Springs	101	5	Thornburg	48	3	4.34	+.29	Fulton	9.90	Alum Fork Reservoir	.77
California	68.2	+.1	Cow Creek	120	25	Boca	22	18	.18	−.16	Bishop Creek	3.86	163 stations	.00
Colorado	63.0	+1.3	Lamar	102	30	Telluride	16	1	1.69	+.28	Cascade	5.32	Garnett	.09
Florida	78.8	−1.0	Marianna	101	[1] 12	Hilliard	56	16	6.71	+.05	Bushnell	14.19	Mason	1.98
Georgia	76.1	−2.0	Stillmore	99	18	Blairsville	48	5	5.49	+1.07	Lafayette	10.55	Hartwell	1.08
Idaho	62.2	+1.8	Swan Falls	100	25	Soldier Creek	17	9	1.40	+.10	Mullan	3.50	2 stations	.19
Illinois	70.6	−1.4	10 stations	95	[1] 23	3 stations	44	[1] 8	5.23	+1.32	Paw Paw	11.07	Carmi	1.90
Indiana	69.8	−1.6	Shoals	100	24	Marengo	42	29	5.22	+1.41	Bluffton	8.77	Madison	1.78
Iowa	69.2	−.3	Logan	102	24	Sibley	38	8	4.66	+.05	Columbus Junction	9.35	Dexter	1.54
Kansas	73.8	.0	Phillipsburg	104	23	Dresden	42	2	4.08	+.10	Garnett	10.55	Syracuse	.70
Kentucky	71.8	−2.0	3 stations	95	[1] 4	Mammoth Cave	45	14	3.93	−.20	Pippapass	8.59	Oneonta	1.31
Louisiana	79.8	−.3	do	98	[1] 15	2 stations	55	[1] 2	4.59	+.01	St. Francisville	11.67	Lake Arthur	1.85
Maryland-Delaware	70.2	−.6	Dundalk, Md	98	12	3 stations	35	1	4.13	+.09	Odessa, Del	9.68	2 stations	1.49
Michigan	63.5	−.5	Adrain	96	24	Chatham	25	27	3.11	+.01	Cassopolis	5.91	Harrisville	1.04
Minnesota	64.9	.0	Redwood Falls	100	21	Hallock	29	8	3.41	−.60	Worthington	7.86	Moorhead	1.04
Mississippi	77.8	−1.1	Hattiesburg	99	[1] 6	2 stations	53	[1] 6	5.25	+1.09	Monticello	9.73	Vicksburg	1.53
Missouri	72.4	−1.2	6 stations	98	[1] 23	Licking (near)	44	2	4.77	+.15	Crystal City	10.05	King City	1.53
Montana	61.5	+1.6	Glendive	99	21	Conway's Ranch	18	10	3.08	+.58	Big Sandy	6.34	Busby	.84
Nebraska	70.8	+1.4	Culbertson	112	30	Gordon	34	26	2.64	−.98	Friend	5.97	Mullen	.50
Nevada	65.5	+1.0	Las Vegas Airport	111	26	Sheldon	24	19	1.08	+.58	Orovada	3.08	Beatty	.00
New England	65.5	+1.5	2 stations	98	[1] 21	Somerset, Vt	30	1	5.50	+2.04	Franklin, Mass	10.04	Chelsea, Vt	1.80
New Jersey	67.2	−1.6	Bridgeton	96	12	Runyon	29	1	7.79	+4.08	Culvers Lake	11.26	Belleplain	3.81
New Mexico	68.4	−.5	4 stations	104	[1] 1	Selsor Ranch	22	2	2.31	+1.04	Carson Seep	8.18	Rodeo	.10
New York	65.5	+.5	Albany	97	21	Indian Lake	30	10	3.64	−.02	Warwick	9.64	Whitehall	.86
North Carolina	72.1	−1.8	Kinston	97	6	Banners Elk	36	14	6.15	+1.45	Scotland Neck	12.59	Hickory	2.71
North Dakota	64.2	+1.1	Washburn	99	21	Mayville	27	8	2.73	−.66	Fryburg	6.52	Hannah	.54
Ohio	68.5	−1.0	Van Wert	97	23	Millport	41	9	4.08	+.28	Ellsworth	7.28	Circleville	1.46
Oklahoma	77.0	−.3	Hollis	104	10	Hooker	45	4	4.37	+.57	Pensacola	9.06	Goodwell	1.35
Oregon	61.3	+1.7	Umatilla	103	5	4 stations	21	[1] 10	.89	−.37	Ukiah	4.00	3 stations	.00
Pennsylvania	67.1	−1.0	Gettysburg	99	26	2 stations	32	1	5.14	+1.02	Coatesville	12.18	Forest City	1.44
South Carolina	75.6	−1.9	Lake City	100	19	3 stations	50	[1] 1	4.80	+.06	Long Creek (near)	9.46	Anderson	1.67
South Dakota	68.3	+1.9	5 stations	100	[1] 5	Aberdeen	31	11	2.72	−.64	Timber Lake	5.90	Huron Airport	1.05
Tennessee	72.6	−2.1	2 stations	95	[1] 25	Tri-City Airport	43	14	4.91	+.72	Bolivar	10.10	Lock 6 Cumb. River	2.05
Texas	80.6	+.4	Fort Stockton	109	3	2 stations	50	[1] 11	3.17	+.21	Hillsboro	11.89	Sabinal	.00
Utah	65.6	+1.0	Springdale (Zion Park).	106	26	do	27	19	.69	+.12	Tremonton	2.18	Leeds (near)	T
Virginia	70.0	−1.6	4 stations	95	[1] 12	Big Meadows	33	1	6.25	+2.06	Halifax	13.61	Mount Weather	1.46
Washington	63.1	+2.4	Grand Coulee Dam	105	21	Paradise Inn	25	9	.76	−.84	Sixprong	2.92	2 stations	T
West Virginia	67.9	−1.7	2 stations	97	[1] 11	Bayard	28	1	5.77	+1.43	Brownsville	9.65	Wardensville	2.15
Wisconsin	64.5	−.6	Mondovi	97	22	Long Lake	30	9	5.15	+1.14	Stanley	9.12	Plum Island	.59
Wyoming	60.2	+1.5	Torrington	96	29	2 stations	21	10	1.52	−.10	Rockypoint	3.72	Seminole Dam	.11
Alaska (May)	42.0	+.7	Richardson	82	23	Barrow	−4	1	2.28	+.71	Cordova	20.90	Matanuska	.02
Hawaii	73.6	+.4	2 stations	92	[1] 23	Kanalohuluhulu	42	22	5.67	+.90	Puohakamoa No. 2	28.00	3 stations	.00
Puerto Rico	77.4	−.5	Juncos	96	10	Garzas	54	28	11.06	+4.70	La Mina (El Yunqus).	31.93	Utuado	3.39

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, June 1938*

[Compiled by Annie E. Small, by official authority U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							64.8	+1.3										78	5.09	+2.1										5.9		
Eastport	76	67	85	29.88	29.96	+0.03	56.8	+1.7	83	21	66	44	2	48	32	53	52	87	3.77	+0.8	17	7.5	sw.	27	sw.	3	5	6	19	7.5	0.0	0.0
Greenville, Maine	1,069	4	41																												
Portland, Maine	103	82	117	29.85	29.97	+.02	64.6	+2.1	91	21	72	50	2	57	27	58	54	74	3.71	+.4	17	7.4	s.	24	n.	19	12	10	8	4.9	.0	.0
Concord	289	54	72	29.68	29.98	+.02	67.4	+4.5	95	21	80	42	1	55	41				5.12	+1.9	13	5.0	se.	18	sw.	7	11	14	5	4.5	.0	.0
Burlington	403	11	48	29.52	29.95	−.01	66.8	+1.1	94	21	78	43	30	55	35	59	53	63	2.04	−1.3	8	8.0	s.	27	s.	2	8	12	10	5.4	.0	.0
Northfield	876	12	60	29.05	29.98	+.02	62.8	+1.5	91	21	77	37	30	48	42	58	54	70	2.23	−1.0	10	6.5	s.	32	sw.	7	8	12	10	5.8	.0	.0
Boston [1]	29	33	62	29.94	29.97	+.01	67.2	+.7	93	21	76	48	1	58	29	61	57	74	6.30	+3.4	12	10.4	sw.	32	ne.	19	7	11	12	6.1	.0	.0
Nantucket	12	14	90	29.98	29.99	+.01	62.4	+1.4	78	19	68	45	1	56	22	60	59	93	6.24	+3.6	11	15.0	sw.	34	ne.	29	7	6	17	7.0	.0	.0
Block Island	26	11	46	29.97	30.00	+.03	62.4	+.6	78	19	68	47	1	57	20	60	58	92	6.53	+3.9	14	13.3	s.	36	w.	5	7	10	13	6.1	.0	.0
Providence	160	215	251	29.82	29.99	+.02	67.0	−1.3	88	25	76	47	1	58	28	61	57	74	7.21	+4.5	13	9.9	s.	27	nw.	12	11	6	13	5.7	.0	.0
Hartford	159	66	100	29.82	29.99	+.02	68.1	+1.0	90	21	78	46	1	58	29				6.18	+3.1	10	8.2	s.	25	s.	7	9	10	11	5.6	.0	.0
New Haven	106	74	153	29.88	29.99	+.02	67.7	+1.1	90	12	76	46	1	59	29	62	59	77	6.66	+3.6	14	8.6	s.	22	ne.	13	3	15	12	6.6	.0	.0
Middle Atlantic States							70.0	−0.3										74	5.64	+1.9									6.4		
Albany [1]	292	26	37	29.66	29.97	.00	68.2	+.2	97	21	81	42	10	56	39	61	56	67	3.52	+.2	11	7.9	s.	27	nw.	7	9	8	13	5.7	.0	.0
Binghamton	871	57	79	29.08	30.00	+.03	66.8	+1.2	92	24	79	42	1	54	36	60	57	74	3.65	+.3	7	5.5	ne.	22	nw.	7	1	10	19	7.9	.0	.0
New York	314	415	454	29.66	29.99	+.01	69.0	+.2	87	7	77	47	1	61	25	62	58	75	7.59	+4.3	14	11.5	s.	44	nw.	7	4	11	15	6.7	.0	.0
Harrisburg	374	94	104	29.60	29.99	.00	70.2	−.1	91	24	80	47	1	60	28	62	57	65	2.92	−.7	11	6.7	s.	24	w.	25	4	17	9	6.1	.0	.0
Philadelphia	114	174	367	29.88	30.01	+.03	71.3	−.1	91	12	80	47	1	62	26	63	59	71	10.06	+6.8	10	11.4	sw.	38	nw.	5	6	11	13	6.4	.0	.0
Reading	323	283	306	29.65	29.99	.....	69.9	+.1	90	7	79	47	1	60	28	62	58	68	5.54	+2.0	15	9.3	se.	39	sw.	26	7	13	10	6.1	.0	.0
Scranton	805	72	104	29.14	29.99	+.01	67.4	−.4	90	24	78	42	1	56	36	60	55	66	4.64	+1.0	13	5.8	n.	32	nw.	7	6	16	8	5.8	.0	.0
Atlantic City	52	37	172	29.95	30.00	+.02	67.1	+.5	85	19	72	46	1	62	22	63	61	86	4.61	+1.6	11	13.4	s.	37	s.	7	5	7	18	7.2	.0	.0
Sandy Hook	22	10	57	29.97	29.99	.....	68.3	+.5	88	25	74	48	1	62	23	63	61	82	7.00	+3.2	13	11.5	s.	34	nw.	5	6	7	17	6.5	.0	.0
Trenton	190	89	107	29.79	29.99	.....	69.9	+.4	91	24	80	43	1	60	33	63	59	74	8.99	+5.9	14	8.1	s.	27	nw.	26	3	10	17	7.4	.0	.0
Baltimore	123	100	215	29.87	29.99	.00	73.1	+.4	95	12	82	48	1	64	28	64	59	65	1.49	−2.4	8	9.6	sw.	37	sw.	12	7	10	13	6.4	.0	.0
Washington	112	62	85	29.88	30.00	.00	72.8	+.6	95	12	82	45	1	63	30	64	60	69	2.26	−1.9	11	5.9	sw.	24	nw.	12	7	13	10	6.1	.0	.0
Cape Henry	18	8	54	29.99	30.01	.....	72.6	−.3	94	12	79	55	1	66	25	68	67	84	6.23	+2.3	13	10.6	sw.	31	nw.	12	7	14	9	5.7	.0	.0
Lynchburg	686	144	184	29.30	30.04	+.03	71.3	−3.3	89	12	82	44	1	61	32	64	61	75	8.25	+4.5	16	6.2	w.	37	nw.	18	4	11	15	6.4	.0	.0
Norfolk	91	80	125	29.92	30.02	+.02	74.5	+.1	92	24	83	53	1	66	22	67	64	77	7.25	+3.0	16	9.2	sw.	32	nw.	23	5	11	14	6.7	.0	.0
Richmond	144	11	52	29.87	30.02	+.01	72.0	−2.1	91	12	81	43	1	63	30	67	64	80	9.28	+5.4	13	7.3	sw.	30	nw.	12	10	8	12	5.8	.0	.0
Wytheville	2,304	49	55	27.69	30.05	+.04	66.4	−2.3	83	24	77	46	1	56	33	60	57	76	2.65	−1.6	14	5.7	w.	24	nw.	17	6	14	10	6.1	.0	.0
South Atlantic States							75.7	−0.8										76	4.98	+0.4									5.7		
Asheville	2,253	89	104	27.74	30.04	+.03	69.6	+.9	87	24	81	51	29	58	31	62	60	79	3.24	−.7	14	6.1	nw.	21	nw.	16	6	9	15	6.3	.0	.0
Charlotte	779	63	86	29.21	30.03	+.02	74.4	−1.1	91	25	84	56	4	65	25	66	62	71	5.14	+.9	10	6.5	s.	21	sw.	23	6	11	13	6.3	.0	.0
Greensboro [1]	886	6	56	29.11	30.05	.....	71.6	.....	89	11	82	48	1	62	30	65	63	78	4.06	.....	15	7.5	s.	26	w.	12	6	12	12	6.3	.0	.0
Hatteras	11	5	50	30.02	30.03	+.02	74.8	−.8	85	19	80	59	1	70	15	70	69	84	3.72	−.8	14	12.1	sw.	33	w.	8	9	15	6	4.9	.0	.0
Raleigh	376	103	140	29.62	30.01	.00	74.0	−1.7	92	12	83	48	1	65	26	67	64	77	8.16	+3.8	15	7.7	sw.	27	sw.	19	7	16	7	5.3	.0	.0
Wilmington	72	73	107	29.96	30.03	+.02	75.6	−1.2	88	8	83	52	1	68	24	69	67	79	5.07	.0	14	9.2	sw.	29	sw.	8	11	12	7	5.1	.0	.0
Charleston	48	11	92	30.00	30.05	+.04	77.6	−1.3	91	5	84	62	1	71	18	71	69	77	3.10	−1.5	9	9.3	s.	22	sw.	25	3	12	15	6.9	.0	.0
Columbia, S. C.	347	70	91	29.67	30.04	+.03	76.9	−1.2	94	6	86	60	1	67	26	68	64	73	6.63	+2.5	16	7.3	s.	26	sw.	8	9	19	2	4.8	.0	.0
Greenville, S. C.	1,039	139	.....	28.95	30.02	.....	74.6	+.5	92	23	85	59	1	64	27	66	62	70	1.75	−2.8	10	5.9	sw.	23	sw.	19	8	13	9	5.9	.0	.0
Augusta	182	62	77	29.83	30.02	+.01	78.2	−.5	94	12	88	62	4	68	25	69	66	74	5.87	+1.2	12	5.1	s.	24	w.	19	6	15	9	5.6	.0	.0
Savannah	65	73	152	29.97	30.04	+.03	78.8	−.2	94	19	87	64	3	70	23	70	68	77	4.57	−.7	11	9.2	sw.	30	se.	25	7	16	7	5.6	.0	.0
Jacksonville	43	86	110	30.00	30.05	+.04	78.7	−1.2	93	24	87	65	16	70	25	71	69	78	7.57	+2.2	14	7.8	sw.	26	w.	20	10	8	12	5.6	.0	.0
Florida Peninsula							79.8	−0.6										77	5.75	−0.4									6.1		
Key West	21	10	64	30.01	30.03	+.04	82.2	+.3	91	28	88	71	24	77	18	75	73	76	3.33	−.9	11	8.3	e.	22	w.	29	4	16	10	6.2	.0	.0
Miami	25	124	168	30.03	30.06	+.06	79.6	−.4	88	7	86	68	24	74	19	74	71	77	5.65	−1.2	15	7.4	se.	26	se.	22	7	12	11	6.1	.0	.0
Tampa	35	88	197	30.02	30.05	+.04	79.6	−.6	94	9	88	67	21	72	21	72	70	78	8.85	+1.6	18	9.1	w.	38	nw.	21	6	13	11	6.0	.0	.0
Titusville	43	5	36	30.00	30.04	.....	77.8	−1.5	92	13	88	63	7	68	27	72	70	...	5.16	−1.1	17	.....	sw.	.....	.....	.....	4	10	16	.....	.0	.0
East Gulf States							78.3	−0.4										74	5.28	+0.6									5.6		
Atlanta [1]	976	5	53	29.02	30.02	+.01	75.2	−.8	94	11	85	59	3	65	29	67	63	72	7.39	+3.6	13	6.5	s.	27	w.	25	4	15	11	6.0	.0	.0
Macon	370	79	87	29.64	30.03	+.02	77.1	−1.8	93	6	87	62	1	67	29	69	65	71	3.17	−.9	11	5.8	s.	18	nw.	26	5	15	10	6.1	.0	.0
Thomasville	273	49	58	29.75	30.04	+.04	78.0	−1.5	94	18	88	62	30	68	27	71	68	...	4.63	−.8	12	.....	sw.	.....	.....	.....	6	16	8	6.0	.0	.0
Apalachicola	35	11	.....	30.00	30.04	.....	79.2	−.6	91	23	86	68	21	72	18	73	71	77	10.87	+5.3	15	7.9	w.	26	nw.	26	10	10	10	5.4	.0	.0
Pensacola	56	149	185	29.98	30.04	+.05	79.4	+.1	90	13	85	68	25	74	18	72	70	75	4.46	−.2	9	10.8	s.	33	nw.	27	6	20	4	5.0	.0	.0
Anniston	741	9	.....	29.28	30.06	+.06	75.2	+.2	91	16	86	57	4	65	28	.....	.....	.....	7.34	+3.2	17	.....	sw.	.....	.....	.....	13	11	6	.....	.0	.0
Birmingham	700	11	48	29.29	30.02	+.03	77.0	−.9	93	16	87	58	29	67	26	68	65	74	3.35	−1.1	13	6.0	s.	26	sw.	9	6	16	8	5.4	.0	.0
Mobile	57	86	161	29.97	30.03	+.04	80.2	−.1	94	14	89	66	30	72	25	72	69	74	4.62	−.8	9	8.3	s.	28	s.	24	6	14	10	5.9	.0	.0
Montgomery	218	92	105	29.79	30.03	+.03	79.3	−.3	94	6	89	63	2	70	24	70	66	70	4.31	+.5	7	6.6	sw.	22	nw.	2	10	13	7	5.2	.0	.0
Meridian	375	67	92	29.64	30.02	+.04	78.6	+.5	95	16	89	60	4	68	30	69	66	78	9.12	+4.6	12	5.0	sw.	20	sw.	7	8	15	7	5.2	.0	.0
Vicksburg	247	82	102	29.76	30.02	+.05	78.2	−.8	93	15	87	64	3	69	23	70	66	73	1.53	−2.5	9	7.4	sw.	26	w.	8	7	11	12	6.2	.0	.0
New Orleans	53	76	84	29.98	30.03	+.05	82.4	+1.8	94	5	90	71	20	75	19	74	70	73	2.57	−3.3	11	6.2	sw.	19	ne.	11	5	17	8	5.7	.0	.0
West Gulf States							80.2	+0.5										74	3.15	−0.4									5.1		
Shreveport	249	92	227	29.74	30.00	+.04	80.6	−.1	96	23	90	66	4	71	25	72	69	73	4.04	+.5	7	8.7	s.	34	n.	11	7	17	6	5.4	.0	.0
Bentonville	1,303	12	38	28.64	29.98	+.04	73.4	−.7	90	24	83	56	3	63	30	.....	.....	...	5.17	+1.0	10	5.8	s.	19	s.	10	7	13	10	.....	.0	.0
Fort Smith	463	57	82	29.53	30.00	+.06	78.2	+.7	94	24	87	62	3	69	25	69	65	68	4.63	+.9	9	7.1	e.	24	s.	21	s.	11	8	16	6	5.3	.0	.0
Little Rock	357	94	102	29.63	30.00	+.04	76.6	−.8	93	15	85	63	3	68	22	69	64	69	2.92	−.8	10	7.3	e.	24	s.	11	9	7	14	5.8	.0	.0
Austin	605	68	90	29.34	29.96	.....	82.2	+1.0	96	21	92	65	9	73	27	73	70	75	3.17	+.7	6	7.3	s.	22	nw	9	14	14	2	4.0	.0	.0
Brownsville	57	88	96	29.88	29.94	.....	81.8	−.6	94	3	89	70	3	75	24	75	73	82	2.55	−.3	9	10.5	se.	25	se.	26	11	16	3	4.6	.0	.0
Corpus Christi	20	11	78	29.94	29.96	+.05	82.6	+1.6	92	3	88	71	3	77	21	76	74	81	.66	−1.9	7	12.3	se.	27	se.	10	10	16	4	4.3	.0	.0
Dallas	512	220	227	29.42	29.96	.....	80.4	.....	94	5	89	64	4	72	26	71	67	68	2.46	−1.4	7	10.7	s.	38	ne.	4	4	20	6	5.8	.0	.0
Fort Worth	679	92	110	29.27	29.97	+.05	81.3	+1.4	94	20	91	67	4	72	24	.....	.....	...	1.61	−1.7	7	9.6	s.	37	s.	10	16	12	2	3.6	.0	.0
Galveston	54	106	114	29.95	30.01	+.06	82.0	+1.3	90	2	86	71	9	78	16	75	73	77	1.29	−3.1	8	10.5	s.	23	s.	9	13	12	5	4.7	.0	.0
Houston	138	292	314	29.86	30.00	.....	81.4	.0	95	28	89	66	9	74	24	.....	.....	...	3.67	−.9	11	10.1	s.	27	nw.	9	3	21	6	5.8	.0	.0
Palestine	510	64	72	29.47	29.99	+.05	80.2	+1.2	92	28	89	65	1	71	22	71	68	73	2.68	−1.0	6	6.7	s.	22	se.	9	6	16	8	5.5	.0	.0
Port Arthur	34	59	134	29.97	30.01	.....	82.0	.....	94	5	89	70	3	75	23	74	72	76	8.64	+3.8	10	11.1	s.	34	e.	13	6	13	11	6.0	.0	.0
San Antonio	693	111	301	29.24	29.95	+.05	82.4	+1.4	95	3	92	68	9	73	23	73	69	73	.65	−1.8	6	10.8	se.	35	e.	22	4	24	2	5.3	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, June 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Mile per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Mi.*								0–10	*In.*	*In.*
							71.3	−1.5										69	4.32	+0.4										6.0		
Chattanooga	762	71	214	29.23	30.02	+0.02	74.7	−0.7	91	11	84	59	3	65	30	67	63	70	7.83	+3.7	13	6.8	w.	31	w.	9	7	12	11	6.1	0.0	0.0
Knoxville	995	66	84	28.99	30.02	+.02	73.2	−.8	90	11	82	58	3	64	29	65	62	72	4.99	+.9	16	5.3	sw.	24	w.	26	10	13	7	3.1	.0	.0
Memphis	399	78	86	29.60	30.01	+.04	76.6	−1.0	92	15	84	63	8	69	22	68	63	68	3.03	−.5	8	7.1	sw.	27	w.	11	10	12	8	5.2	.0	.0
Nashville	546	168	188	29.46	30.04	+.05	73.8	−1.8	89	15	82	56	6	65	31	66	62	71	4.98	+1.0	11	7.6	sw.	30	se.	9	6	12	12	6.2	.0	.0
Lexington	989	6																													
Louisville	525	188	234	29.45	30.03	+.05	72.6	−2.1	89	22	81	57	28	64	25	64	60	68	2.23	−1.6	12	9.3	n.	36	nw.	25	9	13	8	5.7	.0	.0
Evansville	431	76	116	29.55	30.01	+.04	73.4	−1.7	89	23	82	57	28	65	24	65	60	65	3.14	−.9	12	8.1	sw.	36	sw.	10	6	11	13	6.2	.0	.0
Indianapolis	822	194	230	29.14	30.02	+.05	70.3	−1.3	89	23	79	53	27	62	23	61	56	64	6.49	+2.9	8	10.0	s	30	sw.	11	3	18	9	6.5	.0	.0
Terre Haute	575	63	149	29.38	29.99		72.9		93	23	83	54	27	63	27	64	58	64	4.32	+.4	10	8.8	sw.	25	sc.	1	7	13	10	6.1	.0	.0
Cincinnati	627	11	51	29.35	30.02	+.03	70.7	−.5	91	22	81	53	28	61	29	63	59	71	2.29	−1.4	12	6.7	sw.	25	nw.	11	8	8	14	6.1	.0	.0
Columbus	822	90	210	29.14	30.01	+.02	70.3	−.6	92	24	80	53	28	60	31	62	56	62	1.98	−1.3	9	8.9	s.	32	sw.	11	10	10	10	5.9	.0	.0
Dayton	900	186	213	29.06	29.99		69.8	−1.6	89	23	79	53	28	60	26	62	57	65	4.82	+1.0	9	9.1	sw.	30	nw.	26	9	9	12	5.9	.0	.0
Elkins	1,947	65	83	28.04	30.04	+.04	64.4	−2.5	84	26	76	41	1	53	41	60	58	86	5.77	+.7	17	4.8	se.	21	w.	2	4	10	16	7.4	.0	.0
Parkersburg	637	77	84	29.34	30.01	+.01	69.8	−1.6	88	11	80	50	9	60	34	63	59	72	4.70	+.7	15	5.6	se.	21	nw.	11	9	8	13	6.0	.0	.0
Pittsburgh [1]	1,273	39	54	28.68	30.02	+.03	67.6	−3.1	87	24	78	51	1	57	31	60	54	67	3.99	+.2	11	9.0	sw.	34	nw.	11	4	9	17	7.0	.0	.0
Lower Lake Region							67.4	+0.6										66	3.04	−0.3										5.5		
Buffalo	768	243	280	29.17	29.99	+.02	65.1	+.7	84	15	72	54	9	59	26	59	55	73	2.28	−.5	12	12.3	sw.	59	sw.	7	11	8	11	5.4	.0	.0
Canton	448	10	61	29.49	29.95		66.2	+.4	92	21	78	43	30	54	34	59	54	64	2.14	−1.2	9	7.6	sw.	27	w.	7	9	14	7	4.9	.0	.0
Ithaca	836	77	100	29.10	29.99		66.4	+.2	91	24	79	47	14	54	37	59	54	66	2.25	−1.3	11	7.3	nw.	25	s.	2	0	15	15	7.1	.0	.0
Oswego	335	71	85	29.61	29.98	+.01	65.5	+.7	89	24	75	50	9	56	29	59	54	69	2.18	−1.1	7	7.2	s.	27	n.	26	12	8	10	5.3	.0	.0
Rochester	523	86	102	29.43	30.00	+.03	67.8	+1.7	91	25	78	52	8	58	32	59	53	61	1.56	−1.4	9	7.5	sw.	28	w.	7	12	10	8	4.9	.0	.0
Syracuse	596	65	79	29.37	30.01	+.04	68.2	+2.6	91	25	79	51	14	58	29				2.56	−1.3	14	6.6	s.	26	nw.	7	6	14	10	6.0	.0	.0
Erie	714	130	166	29.24	30.00	+.02	66.8	+.6	87	24	75	52	1	59	28	60	56	69	3.38	.0	13	11.1	nw.	32	sw.	6	11	12	7	4.7	.0	.0
Cleveland	762	267	318	29.19	30.00	+.02	68.0	+.9	89	24	76	54	8	60	26	60	54	63	2.45	−.7	11	12.3	s.	41	ne.	12	11	9	10	4.9	.0	.0
Sandusky	629	5	67	29.32	29.99	+.01	69.0	+.2	92	24	79	50	8	59	29				5.68	+2.2	12	8.0	s.	24	sw.	6	6	13	11	5.8	.0	.0
Toledo	628	79	87	29.33	30.01	+.04	68.6	−.1	92	24	78	51	27	59	26	60	55	64	4.28	+1.0	8	9.1	w.	31	w.	7	12	14	4	4.2	.0	.0
Fort Wayne	857	69	84	29.10	30.01		68.4	−.9	90	21	78	52	8	59	26	61	56	66	5.48	+1.9	10	8.6	nw.	32	w.	24	4	16	10	6.1	.0	.0
Detroit [1]	626	5	78	29.32	30.00	+.03	67.6	+.2	92	24	77	48	9	58	29	60	55	65	2.28	−1.3	9	9.5	nw.	30	sw.	6	7	10	13	6.2	.0	.0
Upper Lake Region							63.2	+0.6										73	3.82	+0.4										5.9		
Alpena	609	13	89	29.32	29.98	+.02	62.5	+2.1	86	20	71	45	9	54	28	56	52	72	1.82	−1.5	9	9.8	nw.	29	nw.	2	8	14	8	5.4	.0	.0
Escanaba	612	41	49	29.31	29.96	+.02	60.7	.0	80	24	69	42	8	52	28	56	52	75	2.18	−1.0	14	9.9	s.	26	nw.	4	4	12	14	6.9	.0	.0
Grand Rapids	707	70	244	29.23	29.99	+.02	67.6	−.2	92	23	77	51	13	58	29	60	56	69	3.22	−.3	8	10.0	w.	38	sw.	1	11	6	13	5.8	.0	.0
Lansing	878	5	90	29.06	29.99		65.2	−1.2	91	24	75	47	9	55	29	60	56	74	2.89	−.6	11	7.8	s.	22	sw.	24	6	14	10	5.8	.0	.0
Ludington	637	5	54																												
Marquette	734	44	69	29.16	29.95	+.01	59.4	+.5	87	21	68	43	16	51	29	57	55	83	3.99	+.8	16	7.2	nw.	26	sw.	14	9	12	9	5.8	T	.0
Sault Sainte Marie	614	11	52	29.29	29.98	+.02	57.9	−.7	83	21	67	39	9	48	33	53	50	78	5.14	+2.2	13	6.9	nw.	24	nw.	11	6	12	12	6.3	.0	.0
Chicago	673	7	131	29.28	29.99	+.03	67.6	+.3	88	23	75	54	8	60	22	60	56	72	6.78	+3.5	12	9.1	ne.	25	sw.	15	9	10	11	5.2	.0	.0
Green Bay	617	109	141	29.30	29.97	+.02	65.6	+.7	89	22	74	48	27	57	31	58	53	66	2.03	−1.7	13	10.2	s.	30	ne.	25	7	6	17	6.7	.0	.0
Milwaukee	681	97	221	29.25	29.98	+.03	65.4	+1.5	86	22	73	52	17	58	23	59	55	70	6.93	+3.5	9	11.6	w.	30	n.	25	9	11	10	5.9	.0	.0
Duluth	1,133	5	47	28.73	29.94	+.02	60.2	+3.0	91	22	70	41	7	51	31	55	50	72	3.21	−.7	12	10.1	ne.	32	w.	7	10	11	9	5.6	.0	.0
North Dakota							64.6	+1.5										66	2.18	−1.4										5.5		
Moorhead, Minn	940	50	58	28.93	29.93	+.03	64.8	+.4	93	21	75	40	8	54	39	58	53	69	1.04	−3.0	9	8.5	s.	33	nw.	6	7	12	11	6.1	.0	.0
Bismarck	1,674	8	57	28.16	29.91	+.04	66.8	+3.1	96	21	79	41	8	55	42	57	50	62	3.17	−.2	15	9.7	nw.	37	w.	30	9	11	10	5.7	.0	.0
Devils Lake	1,478	11	44	28.38	29.94	+.06	62.9	+1.0	95	21	75	37	7	51	37	55	50	69	1.36	−2.2	9	9.0	se.	30	nw.	20	8	9	13	6.1	.0	.0
Grand Forks	833	12	67				63.2	+.2	93	21	75	34	8	51	40	57	53		2.07		9	8.4	se.				9	14	12		.0	.0
Williston	1,878	42	50	27.95	29.90	+.04	65.4	+2.7	95	21	76	41	8	54	37	56	50	62	3.13	−.3	9	8.5	se.	30	nw.	6	15	11	4	4.0	.0	.0
Upper Mississippi Valley							70.2	−0.4										68	4.85	+0.7										5.8		
Minneapolis-St. Paul, Minn. [1]	848	32	61	29.05	29.94	+.02	67.9	+.4	94	22	78	45	7	58	33	60	55	66	2.96	−1.3	10	10.3	se.	34	w.	7	8	9	13	6.3	.0	.0
La Crosse	714	11	48	29.21	29.97	+.04	68.0	−.3	93	23	77	48	8	59	27	61	57	73	4.03	.0	11	5.2	s.	17	w.	7	12	7	11	5.5	.0	.0
Madison	974	70	78	28.94	29.97	+.03	66.8	−.4	91	23	75	52	17	58	23	60	56	70	4.24	+.5	13	7.6	s.	21	se.	9	7	9	14	6.6	.0	.0
Charles City	1,015	10	51	28.91	29.98	+.07	67.2	+.7	91	23	77	45	8	57	30	60	56	73	8.09	+3.5	11	6.0	se.	22	s.	9	12	6	12	5.3	.0	.0
Davenport	606	66	161	29.34	29.99	+.05	70.0	−.5	92	23	79	54	27	61	24	62	57	67	6.43	+2.3	14	9.5	sw.	34	sw.	10	8	12	10	5.5	.0	.0
Des Moines	861	5	99	29.07	29.96	+.04	71.2	+.6	97	24	81	51	8	61	29	63	57	65	2.33	−2.4	10	9.0	se.	25	s.	5	8	11	11	5.7	.0	.0
Dubuque	699	60	79	29.24	29.98	+.05	69.0	−.4	91	22	78	50	8	60	27	61	57	69	7.65	+3.3	13	6.0	nw.	21	nw.	25	11	6	13	5.6	.0	.0
Keokuk	614	64	78	29.34	29.98	+.04	71.2	−1.3	94	24	81	55	27	61	26	63	59	67	3.70	−.4	12	7.2	sw.	21	w.	15	6	9	15	6.6	.0	.0
Cairo	358	87	93	29.63	30.00	+.03	74.2	−2.1	92	25	82	60	29	66	22	66	62	70	3.32	−.5	9	7.6	n.	30	nw.	15	7	5	18	6.6	.0	.0
Peoria	609	11	45	29.34	30.00	+.05	69.9	−1.0	94	23	80	50	28	60	27	62	58	71	6.76	+3.0	11	5.9	s.	19	nw.	6	14	8	8	4.5	.0	.0
Springfield, Ill	636	5	191	29.32	29.99	+.04	72.8	+.6	95	25	83	54	28	63	26	63	58	65	4.23	+.2	12	10.2	s.	32	s.	25	5	11	14	6.5	.0	.0
St. Louis	568	179	303	29.40	30.00	+.05	74.2	−.8	94	25	83	58	28	66	26	65	60	65	4.50	+.7	14	10.2	sw.	31	nw.	10	9	14	7	4.9	.0	.0
Missouri Valley							72.3	+1.5										66	3.39	−1.0										5.5		
Columbia, Mo	784	6	66	29.16	29.98	+.03	72.8	.0	94	24	83	55	5	63	28				8.46	+3.7	13	6.8	s.	26	w.	6	9	16	5	5.2	.0	.0
Kansas City [1]	750	32	45	29.18	29.96	+.04	74.0	+.4	97	24	84	54	12	64	28	66	62	70	5.22	+.2	13	8.9	sw.	34	sw.	6	5	12	13	6.4	.0	.0
St. Joseph	967	11	49	28.95	29.96		73.2		97	24	83	53	12	63	29	65	60	68	2.10	−2.8	11	8.0	se.	28	nw.	14	9	13	8	5.2	.0	.0
Springfield, Mo	1,324	98	104	28.62	30.00	+.05	72.6	+.1	90	24	81	58	2	64	24	65	61	72	5.61	+.9	13	8.8	s.	25	sw.	11	12	10	8	5.2	.0	.0
Topeka	987	65	87	28.92	29.96		74.8	+1.4	99	24	86	56	12	64	30	66	61	68	2.58	−2.1	13	9.0	s.	30	w.	14	7	10	13	6.0	.0	.0
Lincoln	1,189	11	81	28.70	29.93	+.03	73.2	+1.8	99	30	84	51	7	62	28	63	58	64	2.89	−1.4	14	9.6	s.	42	sw.	14	8	17	5	5.2	.0	.0
Omaha [1]	982	31	44	28.92	29.94	+.03	72.8	+1.2	98	24	84	49	7	62	31	64	58	64	2.03	−2.5	10	10.9	s.	49	sw.	6	7	11	12	6.2	.0	.0
Valentine	2,598	47	54	27.25	29.92	+.06	69.8	+2.9	94	22	82	43	11	57	39	60	54	62	1.18	−1.7	14	10.0	s.	29	n.	6	7	17	6	5.1	.0	.0
Sioux City	1,138	64	106	28.74	29.92	+.02	71.9	+2.4	98	24	83	50	12	61	34	63	57	63	2.59	−1.4	13	9.6	s.	35	se.	13	6	15	9	5.9	.0	.0
Huron	1,307	59	74	28.56	29.93	+.05	69.2	+3.0	96	22	81	45	11	58	34	60	54	62	1.28	−2.5	13	10.0	se.	34	s.	13	11	13	6	4.7	.0	.0
Northern Slope							63.9	+2.8										60	2.33	+0.1										5.9		
Havre	2,507	11	67	27.32	29.92	+.07	64.5	+2.5	90	21	77	36	7	52	42	54	46	60	3.59	+.7	10	8.4	e.	37	sw.	17	6	13	11	5.9	.0	.0
Helena	4,124	85	111	25.80	29.93	+.05	60.8	+1.6	83	20	72	36	11	50	38	51	43	59	3.36	+1.0	12	7.9	sw.	31	sw.	9	3	9	18	7.5	.0	.0
Missoula	3,263	80	91				63.8	+3.8	87	29	77	35	10	51	40				3.13	+1.2	12	6.8	e.	38	sw.	16	10	5	15	6.0	.0	.0
Kalispell	2,973	48	56	26.92	29.92	+.03	61.4	+3.7	84	4	74	38	11	49	38	52	44	61	1.17	−.9	9	6.1	nw.	26	w.	8	2	12	16	7.0	.0	.0
Miles City	2,371	48	55	27.43	29.87	+.02	68.7	+2.7	97	21	81	42	11	57	37	57	48	55	2.96	+.3	9	6.7	ne.	32	w.	8	9	11	10	5.5	.0	.0
Rapid City	3,259	50	58	26.60	29.90	+.05	67.0	+2.8	92	21	79	44	11	55	35	57	50	59	3.57	+.2	14	7.9	n.	41	w.	18	13	13	4	4.7	.0	.0
Cheyenne [1]	6,144	5	39	24.01	29.91	+.07	61.8	+1.4	84	28	76	39	1	48	39	52	47	67	2.02	+.4	14	10.2	w.	38	sw.	20	4	15	11	6.3	.0	.0
Lander	5,352	60	68	24.65	29.86	+.01	64.4	+3.9	87	26	79	38	10	50	40	49	38	45	.14	−1.0	7	5.8	sw.	41	sw.	20	8	16	6	5.0	.0	.0
Sheridan	3,790	10	47	26.09	29.93		63.4		88	12	77	34	11	50	45	55	49	67	2.29	+.2	13	4.8	nw	22	nw	8	9	17	4	4.9	.0	.0
Yellowstone Park	6,241	12	46	23.93	30.01	+.15	55.8	+2.4	80	5	69	31	10	42	40	46	39	62	.83	−.8	13	7.5	sw.	34	sw.	8	4	14	12	6.2	.0	.0
North Platte	2,821	11	51	27.05	29.91	+.05	71.0	+3.5	99	22	83	48	8	59	36	61	56	66	2.62	−.6	9	8.3	se.	29	sw.	13	9	14	7	5.8	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, June 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Mile per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Mi.*								*0–10*	*In.*	*In.*
Middle Slope							**72.7**	**+0.8**										**64**	**3.18**	**+0.1**										**5.2**		
Denver	5,292	106	113	24.76	29.92	+0.08	67.8	+1.5	91	21	79	49	8	56	33	54	46	54	1.65	+0.3	15	7.9	s.	30	s.	12	5	16	9	6.2	0.0	0.0
Pueblo	4,685	80	86	25.31	29.90	+.07	70.6	+1.6	94	21	84	47	14	57	36	56	47	53	.79	−.6	11	7.7	e.	37	sw.	13	7	17	6	5.4	.0	.0
Concordia	1,392	50	58	28.51	29.95	+.05	72.8	−.2	96	30	83	53	7	62	27	65	61	70	5.17	+.8	9	8.7	s.	24	sw.	14	9	17	4	4.7	.0	.0
Dodge City	2,509	10	86	27.38	29.93	+.06	73.3	+.8	96	23	85	52	7	62	32	63	58	65	1.50	−1.8	10	12.6	s.	44	nw.	10	10	15	5	4.8	.0	.0
Wichita	1,358	85	93	28.54	29.94	+.03	74.6	+.2	94	24	84	57	2	65	29	66	61	66	4.49	+.1	11	10.2	se.	27	s.	30	12	14	4	4.7	.0	.0
Oklahoma City	1,214	10	47	28.69	29.94	+.03	76.8	+.8	94	6	86	60	11	67	29	68	65	73	5.45	+1.8	11	8.4	s.	29	w.	6	5	15	10	5.7	.0	.0
Southern Slope							**79.4**	**+1.5**										**58**	**2.69**	**+0.2**										**4.6**		
Abilene	1,738	10	56	28.15	29.91	+.03	81.3	+2.1	99	3	93	63	4	70	32	68	63	61	5.92	+2.9	10	10.0	se.	32	s.	9	11	13	6	4.8	.0	.0
Amarillo	3,676	10	49	26.28	29.92	+.07	75.0	+2.2	96	6	87	55	8	63	34	62	55	60	2.49	−.4	9	10.0	se.	28	e.	15	7	18	5	5.0	.0	.0
Del Rio	960	63	71	28.90	29.86	+.01	84.4	+1.0	100	3	94	72	10	75	26	70	64	56	.60	−2.0	8	11.6	se.	30	se.	21	13	11	6	4.6	.0	.0
Roswell	3,566	75	85	26.35	29.87	+.07	77.0	+.7	100	3	90	56	9	64	40	61	52	53	1.76	+.1	12	8.9	s.	38	nw.	15	12	14	4	4.2	.0	.0
Southern Plateau							**74.7**	**+0.7**										**36**	**1.18**	**+0.8**										**3.6**		
El Paso	3,778	82	101	26.13	29.79	+.04	81.2	+1.6	100	3	93	63	14	69	34	60	44	36	2.82	+2.2	7	8.6	e.	27	se.	7	15	9	6	3.9	.0	.0
Albuquerque [1]	4,972	5	39	25.04	29.80	.....	73.2	+.6	97	20	89	44	14	58	42	55	41	41	1.51	+1.0	7	10.2	se.	50	nw.	6	10	13	7	4.7	.0	.0
Santa Fe	7,013	38	53	23.32	29.88	+.07	66.4	+1.6	84	3	78	45	8	55	32	51	40	45	2.70	+1.6	10	7.4	se.	29	ne.	8	4	17	9	6.2	.0	.0
Flagstaff	6,907	10	59	23.48	29.80	.....	59.6	+.3	87	25	78	30	19	42	44	43	----	36	.87	+.5	3	8.9	sw.	32	s.	12	7	19	4	----	.0	.0
Phoenix	1,107	39	51	28.61	29.73	−.01	85.8	+1.3	112	5	101	63	13	70	38	60	39	25	.28	+.2	2	6.6	e.	30	e.	26	21	8	1	2.3	.0	.0
Yuma	141	9	54	29.59	29.73	−.01	85.2	+.5	111	5	102	61	12	68	42	63	47	34	T	.0	0	5.6	w.	19	se.	28	26	4	0	.9	.0	.0
Independence	3,957	5	26	25.90	29.86	+.08	71.5	−.8	97	25	86	42	20	57	38	53	38	----	.11	.0	1	-----	n.	----	----------	----	21	4	5	----	.0	.0
Middle Plateau							**67.0**	**+2.0**										**44**	**1.02**	**+0.6**										**4.5**		
Reno	4,529	61	76	25.43	29.88	+.02	65.4	+3.0	92	25	79	37	19	51	40	52	42	51	1.31	+1.0	8	6.5	w.	25	ne	20	16	7	7	4.0	.0	.0
Tonopah	6,090	12	20	----	----	----	65.6	----	92	25	78	36	18	53	32	50	38	45	.65	----	5	9.4	w.	26	nw.	17	----	----	----	3.7	.0	.0
Winnemucca	4,344	18	56	25.57	29.89	+.01	65.0	+2.2	92	25	81	36	18	49	44	50	39	49	1.55	+.8	11	7.5	sw.	27	w.	15	12	6	12	4.9	T	.0
Modena	5,473	10	43	24.57	29.80	−.02	64.2	+.9	92	26	82	37	21	47	43	47	32	37	.23	−.1	2	10.5	sw.	37	w.	8	15	9	6	4.1	.0	.0
Salt Lake City [1]	4,227	32	46	25.66	29.82	−.03	67.8	.....	93	26	83	40	19	53	40	53	40	41	.12	----	5	9.3	s.	45	w.	17	11	10	9	4.9	.0	.0
Grand Junction	4,602	60	68	25.33	29.84	+.01	73.2	+1.8	94	17	86	48	14	60	35	55	44	41	.98	+.6	11	8.4	se.	36	s.	21	8	15	7	5.3	.0	.0
Northern Plateau							**66.8**	**+3.1**										**48**	**0.95**	**−0.1**										**4.8**		
Baker	3,471	36	54	26.44	29.96	+.01	61.6	+3.0	88	24	76	34	10	47	44	50	41	53	.71	−.6	5	6.1	n.	21	n.	8	8	11	11	5.6	.0	.0
Boise	2,739	79	87	27.10	29.91	.00	67.0	+1.7	94	25	81	39	10	54	40	55	45	52	1.29	+.4	9	5.8	se.	19	se.	29	12	7	11	4.8	.0	.0
Pocatello	4,477	60	68	25.44	29.89	+.02	64.6	+2.4	92	26	79	37	10	50	42	50	40	49	1.12	.0	9	8.0	se.	34	sw.	17	11	10	9	5.4	.0	.0
Spokane	1,929	101	110	27.91	29.92	−.02	66.8	+4.0	90	21	80	41	10	54	36	53	43	49	.83	−.4	5	6.6	s.	23	ne.	21	9	17	4	4.7	.0	.0
Walla Walla	991	57	65	28.87	29.93	−.03	70.6	+4.1	94	7	83	45	9	58	37	55	43	43	.95	−.2	6	5.8	s.	18	sw.	7	13	11	6	4.3	.0	.0
Yakima	1,076	58	67	28.81	29.94	.....	70.0	+3.6	95	4	84	44	9	57	37	55	43	43	.81	+.2	5	7.3	nw.	26	nw.	30	14	8	8	4.3	.0	.0
North Pacific Coast Region							**61.1**	**+1.7**										**68**	**0.29**	**−1.4**										**5.1**		
North Head	211	11	56	29.88	30.10	+.11	54.2	−.6	72	6	57	47	10	51	23	52	50	87	.31	−2.0	6	15.6	nw.	34	nw.	8	5	7	18	7.1	.0	.0
Seattle	125	90	321	29.91	30.04	+.04	62.7	+3.7	85	21	72	46	9	53	28	54	48	63	.39	−.9	2	8.0	n.	23	s.	16	11	7	12	5.4	.0	.0
Tacoma	194	172	201	29.85	30.05	+.02	61.1	+2.4	82	22	70	44	10	52	29	----	----	----	.10	−1.4	1	8.6	n.	----	----------	----	----	----	----	5.5	.0	.0
Tatoosh Island	86	10	54	29.99	30.09	+.07	52.2	−.8	70	6	56	44	10	49	22	50	48	88	.63	−2.6	10	10.1	sw.	27	w.	8	7	10	13	6.4	.0	.0
Medford [1]	1,329	29	58	28.58	29.97	.....	67.8	+2.6	99	4	84	41	9	51	47	54	43	50	.01	−.7	1	-----	nw.	----	----------	----	----	18	9	3	3.1	.0	.0
Portland, Oreg.	154	68	106	29.88	30.04	.00	64.9	+2.5	92	6	75	46	9	54	34	56	49	61	.45	−1.1	4	7.1	nw.	17	nw.	4	10	12	8	4.8	.0	.0
Roseburg	510	45	76	29.48	30.03	.00	64.9	+2.4	96	6	79	42	10	51	44	55	47	60	.12	−1.0	2	5.7	n.	18	sw.	16	19	3	8	3.7	.0	.0
Middle Pacific Coast Region							**65.4**	**+1.1**										**62**	**T**	**−0.5**										**4.2**		
Eureka	60	72	88	29.97	30.04	−.01	53.2	−1.1	61	16	57	47	2	49	12	50	49	86	.01	−.7	1	8.1	n.	27	n.	8	5	9	16	6.9	.0	.0
Redding [1]	722	20	34	----	----	----	79.2	+4.1	103	6	92	55	18	66	34	59	43	32	T	−.8	0	8.8	nw.	27	nw.	16	18	9	3	3.0	.0	.0
Sacramento	66	92	115	29.76	29.83	−.06	71.7	+2.3	99	23	86	51	10	57	38	59	50	52	T	−.2	0	8.4	s.	25	nw.	19	21	8	1	2.1	.0	.0
San Francisco	155	112	132	29.74	29.91	−.05	57.5	−1.0	72	14	63	50	24	52	19	52	49	80	.00	−.2	0	10.7	w.	26	w.	23	12	12	6	4.7	.0	.0
South Pacific Coast Region							**68.7**	**0.0**										**64**	**0.02**	**0.0**										**4.3**		
Fresno	327	97	105	29.48	29.82	−.03	77.6	+1.8	102	23	92	54	11	63	36	60	46	39	.05	.0	1	7.4	nw.	21	w.	19	22	6	2	2.2	.0	.0
Los Angeles	338	159	191	29.55	29.91	+.01	65.4	−1.0	82	1	73	55	13	58	24	59	55	75	T	−.1	0	5.7	sw.	14	se.	19	8	15	7	4.8	.0	.0
San Diego	87	62	70	29.82	29.91	−.01	63.2	−.7	70	25	67	56	2	59	12	58	56	78	.01	.0	1	7.3	w.	16	w.	20	8	11	11	5.9	.0	.0
West Indies																																
San Juan, P. R	82	9	54	29.97	30.06	.....	79.0	−.7	89	2	83	70	13	75	12	----	----	----	11.76	+6.5	17	14.4	e.	33	e.	10	8	15	7	5.3	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	----	----	----	----	----	----		----	----		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Cristobal	36	6	97	----	----	----	----	----	----		----	----		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Alaska																																
Fairbanks	454	11	87	[3]29.26	[3]29.76	.....	57.2	−.9	89	27	70	36	16	45	39	48	40	59	.40	−1.0	5	6.7	s.	23	n.	12	2	14	14	7.1	.0	.0
Juneau	80	96	116	[3]29.92	[3]30.01	.....	51.0	−3.3	77	23	57	39	2	45	30	47	43	77	8.91	+3.5	21	7.6	se.	30	se.	18	4	3	23	8.1	.0	.0
Nome	22	5	32	[3]29.80	[3]29.82	.....	47.6	+2.2	67	12	56	29	19	39	44	39	71	71	1.36	+.2	7	8.9	sw.	29	ne.	5	8	12	10	5.3	T	.0
Hawaiian Islands																																
Honolulu	38	86	100	29.99	30.03	.....	76.6	.0	84	22	81	68	21	72	15	69	66	71	1.00	+.1	12	8.9	e.	25	e.	28	13	8	9	5.1	.0	.0

[1] Observations taken at airport.
[3] Observations taken hourly.
[4] Pressure not reduced to mean of 24 hours.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, June 1938*

Station	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48	29.89	29.94	−0.01	61.9	+6.5	72.1	51.7	88	41	3.97	+1.12	0.0
Halifax, Nova Scotia	88	29.73	29.99	+.03	61.2	+3.4	68.8	53.5	84	48	5.43	+1.45	.0
Yarmouth, Nova Scotia	65	29.87	29.99	+.03	57.0	+1.8	64.5	49.6	77	40	5.89	+2.95	.0
Charlottetown, Prince Edward Island	38	29.86	29.94	+.01	63.1	+5.7	71.5	54.7	84	45	2.47	−.41	.0
Chatham, New Brunswick	28	29.80	29.91	.00	64.0	+4.3	75.6	52.5	93	41	3.20	−.32	.0
Father Point, Quebec	20	29.86	29.88	.00	57.2	+4.5	65.5	48.9	74	40	2.04	−1.17	.0
Quebec, Quebec	296	29.62	29.94	+.04	65.4	+4.1	74.8	56.0	90	47	2.73	−1.27	.0
Doucet, Quebec	1,236	28.61	29.94	+.03	57.0	+1.9	71.5	42.6	89	26	3.10	−.85	.0
Montreal, Quebec	187	29.76	29.96	+.05	67.3	+2.6	75.8	58.9	88	51	3.36	−.12	.0
Ottawa, Ontario	236	29.66	29.92	.00	64.6	+.1	76.9	52.2	92	41	2.43	−.76	.0
Kingston, Ontario	285	29.66	29.96	+.02	64.2	+1.6	71.9	56.4	81	48	2.84	−.06	.0
Toronto, Ontario	379	29.58	29.98	+.01	65.8	+1.6	75.8	55.8	88	47	1.49	−1.32	.0
Cochrane, Ontario	930	28.89	29.89	−.03	59.5	+1.3	70.1	49.0	90	34	3.41	+.63	.0
White River, Ontario	1,244	28.62	29.94	+.02	56.3	−.9	68.4	44.2	85	31	6.01	+3.53	.0
London, Ontario	808	29.12	29.98	+.01	62.6	−2.2	73.2	52.1	87	39	1.85	−1.20	.0
Southampton, Ontario	656	29.28	29.98	+.03	60.2	−.1	69.2	51.3	82	40	1.60	−.95	.0
Parry Sound, Ontario	688	29.30	29.98	+.04	62.2	+.3	72.0	52.5	83	43	2.70	+.22	.0
Port Arthur, Ontario	644	29.26	29.96	+.03	56.6	−.4	67.0	46.3	82	31	2.94	+.09	.0
Winnipeg, Manitoba	760	29.10	29.94	+.03	62.2	−.2	74.2	50.1	93	30	1.32	−1.76	.0
Minnedosa, Manitoba	1,690	28.16	29.96	+.09	59.4	−.5	72.2	46.6	87	30	1.62	−1.36	.0
Le Pas, Manitoba	860	28.96	29.92	+.04	62.3	+3.1	75.6	48.9	92	38	.97	−1.25	.0
Qu'Appelle, Saskatchewan	2,115	27.68	29.94	+.07	60.8	+1.1	72.2	49.5	87	31	2.92	−.57	.0
Moose Jaw, Saskatchewan	1,759	27.96	29.92	+.09	62.8	+2.5	74.6	51.0	89	35	1.94	−1.10	.0
Swift Current, Saskatchewan	2,392	27.40	29.92	+.06	62.6	+2.4	74.3	51.0	88	34	1.97	−.99	.0
Medicine Hat, Alberta	2,365	27.46	29.92	+.06	63.9	+.8	75.5	52.3	92	36	2.02	−.44	.0
Calgary, Alberta	3,540	26.34	29.96	+.08	58.0	+2.1	69.6	46.4	84	23	2.58	−.61	2.0
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.41	29.93	+.05	62.1	+3.4	74.0	50.2	90	36	.44	−2.33	.0
Battleford, Saskatchewan	1,592	28.20	29.92	+.05	60.6	+2.2	74.6	46.6	93	31	1.32	−1.56	.0
Edmonton, Alberta	2,150	27.66	29.90	+.06	60.9	+3.6	72.7	49.1	87	36	4.80	+1.71	.0
Kamloops, British Columbia	1,262	28.66	29.96	+.04	69.8	+5.3	84.0	55.6	101	44	.44	−.88	.0
Victoria, British Columbia	230	29.80	30.05	+.03	57.7	+.7	65.7	49.7	77	45	.02	−.88	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20	30.08	30.10	+.06	54.2	+1.2	59.3	49.0	69	41	.51	−3.21	.0
Prince Rupert, British Columbia	170	29.89	30.08	+.06	51.6	−1.6	58.6	44.7	70	41	3.75	−2.3	.0
St. George's, Bermuda	158		30.19	+.07	77.3	+2.9	82.8	71.7	88	65	2.80	−2.13	.0
LATE REPORTS FOR MAY, 1938													
Quebec, Quebec	296	29.59	29.91	−0.03	51.8	+0.9	60.5	43.0	76	30	3.42	+0.09	0.0
Montreal, Quebec	187	29.71	29.92	+.01	55.3	+.2	63.6	47.0	75	39	3.72	+.69	.0
Winnipeg, Manitoba	760	29.09	29.92	−.06	51.8	−.2	63.0	40.7	79	27	1.60	−.59	.0
Le Pas, Manitoba	860	29.03	30.00	+.02	48.4	+.7	59.9	36.9	86	25			

TABLE 4.—*Severe local storms, June 1938*

(Compiled by Mary O. Souder from reports submitted by Weather Bureau officials)

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Chicago, Ill., and vicinity	1					Thundersquall	A filling station, hospital, 2 street cars and several residences struck by lightning.
Butler County, Ala., western portion.	2				$1,200	Hail	Loss to crops.
Rotan, Tex	3	7 p. m	[1] 2–5		150,000	do	Property damage, $100,000; crop loss, $50,000.
Claremore, Okla	3	8:15 p. m	[1] 2	0	40,000	Tornado and hail	Several buildings destroyed; windows broken. Crop loss, $15,000; property damage, $25,000. Path 15 miles long.
Grandfield, Okla	3	8:40 p. m	[1] 6	0	350,000	Tornado and heavy hail.	Several buildings and many homes destroyed. Crop loss, $200,000; property damage, $150,000; path 25 miles long.
Wichita Falls, Tex., and vicinity.	3	9:30 p. m	[1] 20		50,000	Wind	Property damaged; 2 persons injured.
Chesterfield County, Va	5	3–4 p. m	1,000		10,000	Hail	Damage limited to crops, principally to corn and gardens.
Merna to Arnold, Nebr	5	6–7 p. m	[1] 3–6		25,000	do	Hail 3 inches deep in places, some stones as large as hen eggs.
Buffalo, N. Y	5				15,000	Thunderstorm	Medical laboratory struck by lightning.
Hector, N. Y	5		[1] 3		8,000	Heavy hail	Loss to fruit; path 6 miles long.
Clinton County, Iowa	6	2 p. m			5,000	Hail	Property damage, $2,000; loss to crops, $3,000.
Chicago, Ill	6	3:34–8:33 p. m.				Thunderstorm	Some damage from lightning.
Cowley County, Kans	6	6 p. m			100,000	Heavy hail	$60,000 damage chiefly to wheat and orchards, 2 to 12 miles, southwest of Winfield. In the vicinity of Burden, $40,000 damage over a path 2 miles wide and 6 miles long with loss chiefly to wheat.
Colchester, Ill	6				3,500	Wind	Barns demolished; horse killed.
Detroit, Mich.,[2] and vicinity	6					Thundersqualls	Lightning struck a power line at Grosse Pointe park, leaving the village in darkness for nearly 5 hours.
Jackson County,[2] Mich., and vicinity.	6					Wind, electrical	Homes and barns destroyed, livestock killed and electric service disrupted. Six manufacturing plants closed because of no power.
Gouverneur, N. Y	7	A. m			2,500	Thunderstorm	Large barn burned.
Ogdensburg, N. Y	7	do			3,000	do	Barn and silo destroyed.

[1] Miles instead of yards.

[2] From press reports.

TABLE 4.—*Severe local storms, June 1938*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Hillsboro, Va., vicinity of	7	7 p. m.	100		$500	Small tornado	Several trees snapped off; blinds of a house torn to bits. Funnel shape of cloud rather clear-cut.
Lunenburg, Vt., vicinity of	7	P. m.		2		Electrical and wind.	2 men electrocuted by a high tension wire blown down in the storm.
East Homer, N. Y.	7					Wind	Buildings unroofed; garage and trees blown down.
Syracuse, N. Y.	7					do	Trees and limbs blown down; power lines damaged.
Theresa, N. Y.	7				1,300	Thunderstorm	15 cattle killed by lightning in a pasture.
Burlington, Rutland, Middleburg, and Randolph, Vt., and vicinities.[1]	7					Thundersquall	Manager of the New England Telephone and Telegraph Company reported 20 main circuits out between Montreal and New York. Trees uprooted and property damaged.
York County, S. C.	8	3 p. m.	880		1,500	do	Property damaged; path 6 to 8 miles long.
Abilene, Tex.	8	7:18–7:45 p. m.				Hail	Gardens and shrubbery damaged considerably; some damage to roofs, and automobile tops.
Paducah, Tex.	8		[1] 1–3		10,000	do	Loss to crops.
Brown and Day Counties, S. Dak.	9	1:30–2:30 a. m.			20,000	Wind, rain, and hail.	Crop loss, $15,000; property damage, $5,000; path 20 miles long.
Dearborn County, Ind.	9	p. m.			4,400	Electrical	House destroyed by fire.
Walterboro, S. C., vicinity of	9				1,000	Thundersquall	Trees uprooted; houses unroofed.
Monument to Colby and Levant, Kans.	10	3–5 p. m.	[1] 2–10		225,000	Heavy hail	Loss mostly to wheat over a path 35 miles long.
Abilene, Tex., and vicinity	10	4:28–4:38 p.m.				Hail	Some stones as large as baseballs. A few stones struck the American Airlines, Inc., west-bound plane about 18 miles east of Abilene at 5:43 p. m., breaking 2 wind shields and making 8 or 10 large dents in its wings. Only small damage reported.
Rooks County, Kans.	10	4:30 p. m.	[1] 1–3		100,000	Heavy hail	50 to 100 percent loss in wheat; roofs, gardens, and trees damaged; path 20 miles long.
Plainville, Kans., vicinity of	10	5 p. m.	33	0	250	Tornado	Path 4 miles long.
Loup County, Nebr.	10	do	[1] 3		5,000	Hail	Property damaged.
Lebo, Kans., vicinity of	10	5:30 p. m.	400	0	36,000	Tornado	Damage to farm buildings; cattle killed. Crop loss, $1,000; path 4 miles long.
Ness and Trego Counties, Kans.	10	6 p. m.	[1] 2–3		5,000	Heavy hail	Loss to wheat along the line of the counties mentioned; path 12 miles long.
Plainville, Kans., vicinity of	10	do	300	0	2,000	Tornado	Small buildings damaged; wire service interrupted; path 2 miles long.
Garnett, Kans., and vicinity	10	6:30 p. m.	100–133	0	40,000	do	Several small, whirling clouds observed; 2 persons injured; damage to buildings, trees, and wires; 4 cars blown from freight train; path 12 miles long.
Great Bend, Kans.	10	7–8 p. m.	[1] 6		40,000	Hail and wind	Crop loss, mostly to wheat, $25,000; property damage, $15,000; path 12 miles long.
Clyde, Tex.	10	7:39–8 p. m.	300	14	110,000	Tornado	Public school building and 21 residences wrecked. 9 persons injured; property damaged, $75,000; loss to orchards, crops, and vineyards, $25,000; damage to railroad, $10,000. The storm struck a freight train standing on the Texas and Pacific Railway track; 19 cars were blown off the track, 2 cars near each end of the string being carried entirely clear of the right-of-way.
Kennedy to Enders Lake, Nebr.	10	8 p. m.	[1] 3		5,000	Hail	Property damaged.
Pawnee County, Kans.	10	8–8:30 p. m.			500,000	Wind	Greater part of county affected. Farm buildings unroofed and otherwise damaged.
Russell, Kans., 17 miles northwest of.	10	8:15 p. m.	[1] 8		30,000	Hail	Loss to wheat; path 7 miles long.
Woodbine, Kans.	10	8:30 p. m.	33	0	200	Tornado	Damage to small buildings and trees.
Rice and Reno Counties, Kans.	10	9–10 p. m.			400,000	Wind and hail	Most of damage due to wind. About $300,000 loss to crops, mostly wheat; $100,000 property damage.
Saline County, Kans.	10	9:30 p. m.		0	5,000	Tornado	2 whirling clouds seen; damage to farm property; path 12 miles long.
Florence, Kans., 1½ miles south	10	10 p. m.	17	0	400	do	Path a mile long.
Harvey, Marion, and Chase Counties, Kans.	10	do	50	0	5,000	do	3 persons injured; damage to farm buildings; path 30 miles long.
Tampa, Hillsboro, Peabody, and Antelope, Kans., and vicinities.	10	do			400,000	Wind	Much damage to small buildings and electric poles. Loss to wheat, $350,000.
Neosho, Allen, and Anderson Counties, Kans	10	11:30 p. m.			4,500	do	Minor damage to many buildings, trees, and poles. Crop loss, $500.
Gove County, Kans.	10	P. m.	[1] 4			Heavy hail	Many fields of wheat a total loss; amount not estimated.
Lane and Ness Counties, Kans.	10		[1] 2		3,000	do	Loss in wheat; path 8 miles long.
Union, Mo.	10					Wind	Trees and electric lines damaged.
Custer County, Nebr.	10				25,000	Hail	Property damaged.
Concordia, Kans., vicinity of	10–11					Heavy rain	Creeks overflowed with some damage to highways and small bridges. Loss to growing crops.
Meade County, Kans.	10, 14 & 15				500,000	do	Hailstorms on 3 afternoons. Details of separate storms not available. Loss to wheat.
Big Spring, Tex.	11	5 p. m.	[1] 15		20,000	Wind	1 person seriously injured; property damaged; $10,000; crop loss, $10,000.
Stanton, Tex.	11	6 p. m.	1,320	0	90,000	Tornado	Loss to crops, $75,000; property damaged, $15,000.
Cedar Rapids, Iowa	11	P. m.		1		Rain, electrical	Street flooded by excessive rain; man killed by lightning.
Cadiz, Ohio	11	do				Thundersquall	Trees blown down; several buildings unroofed.
Edwardsville, Ill.	11				6,000	Wind	Damage to trees, wires, and buildings.
Dauphin County, Pa.	12				40,000	Tornado	7 barns wrecked; buildings damaged. Crops loss, $20,000 property damaged, $20,000; path narrow.
Hamilton County, Fla., south-central portion.	13		[1] 2		2,500	Squall	Property damaged; path 8 miles long.
Haskell County, Kans.	14	Noon	[1] 2		20,000	Heavy hail	Loss chiefly to wheat; path 15 miles long.
Pawnee and Edwards Counties, Kans.	14	2 p. m.	[1] 2			do	Entire loss not estimated. Damage in Pawnee County, $30,000. 10 to 70 percent to wheat over scattered areas.
Seward and St. John, Kans.	14	do	[1] 12		250,000	Heavy hail and wind.	Loss mostly to wheat crop due to hail; path 20 miles long.
Clay and Becker Counties, Minn.	14	5 p. m.	[1] 4		5,000	Thundersquall	A number of farm and town buildings destroyed; length of path about 70 miles.
Clay, Becker, and Beltrami Counties, Minn.	14	5–9 p. m.	[1] 3–4		51,500	Hail and rain	At Georgetown, Clay County, the hailstones accumulated to a depth of about 4 inches in places. Most of damage to headed rye and gardens; path from 6 to 10 miles long.
Dubuque, Iowa	14	5:30 p. m.			500	Thundersquall	Many streets, roads, and hillside cornfields and gradens washed out; buildings flooded; electric and power lines damaged. Considerable damage to a number of houses because of falling trees. A record of 3.24 inches of precipitation, greatest amount in 2 hours, recorded during this storm.
Arnett, Okla.	14	6 p. m.	[1] 2–10		500,000	Wind and hail	The storn area extended from Higgins, Tex., to beyond Gage, Okla.; path 25 miles long. Wheat, almost ready for harvesting and excellent in quality, completely destroyed; crop loss, $500,000.
Berryton, Kans., vicinity of	14	7 p. m.	67	0	1,000	Tornado	Farmhouse damaged; outbuildings demolished; some damage to trees; path 5 miles long.
Walthill, Nebr.	14	do	[1] 2		2,000	Wind and rain	Damage to trees, gardens, and crops.
Midland, Kans.	14	7:30 p. m.	[1] 1		500	Wind	Path 15 miles long.
Nemaha and Brown Counties, Kans.	14		[1] 15		25,000	do	Loss to growing crops, $24,000; path 25 miles long.
Burlington Junction, Mo.	14					do	Considerable damage to barns, outbuildings and trees.

[1] Miles instead of yards.

[1] From press reports.

TABLE 4.—*Severe local storms, June 1938*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Memphis, Tex.	14				$6,000	Hail	Property damaged.
Haskell County, Kans., northeast portion.	15	7 p. m.	[1] 1		10,000	Heavy hail	Chief loss to wheat over a path 5 miles long.
Superior and St. Regis, Mont.,[2] and vicinities.	15–17					Heavy rain and hail.	Considerable flooding. At a point on the highway between Superior and St. Regis, hail fell in such quantities that it lay for many hours in drifts like snow.
New Plymouth, Idaho	16	1:45 p. m.	[1] 2		20,000	Heavy hail	Loss to fruit, small grains, and corn; path 6 miles long.
Eureka, Mont., vicinity of	16	2–3 p. m.	2,640		5,200	Hail and rain	Chickens killed; roads and highways washed by heavy rain; loss to gardens and hay, $2,000.
Stanton and Cuming Counties, Nebr.	16	6 p. m.	[1] 2		2,000	Hail	Property damaged.
Gallipolis, Ohio, vicinity of	16				3,000	Heavy hail	No details.
Logan County, W. Va.	16					do	Considerable loss to crops and damage to property.
Fountain Inn, S. C.	17	2:18–4 p. m.	880		700	Thundersquall and hail.	Property damaged; path 1½ miles long.
Chouteau County, Mont.	17	3 p. m.	880–3,520		10,000	Hail	Loss to crops; damage to pasutres and range.
Helena, Mont.,[2] 8 miles west	17	4 p. m.				Cloudburst	Small section of track on the Northern Pacific system washed out.
Fairview, S. C.	17	do	880		700	Hail	Loss to crops; path 1½ miles long.
Neosho County, Kans.	17	4:40 p. m.		0		Small tornado	Appeared east of Chanute, Kans.; lasted 10 minutes and did not reach the ground.
Delanson, N. Y.	17	5:45 p. m.	100			Tornadic winds	Funnel-shaped cloud observed. Siding on one side of farmhouse carried away. Total loss less than $1,000; path 2 miles long.
Pueblo, Colo., and vicinity	17					Hail	In some sections snow shovels were used to clear paths and driveways. Portions of the city entirely escaped the storm. Trees and gardens heavily pounded by hail; some crops 100 percent loss; thousands of dollars' loss reported.
Bazine, Kans.	17		[1] 2		2,000	Heavy hail	Loss to wheat; path 8 miles long.
Melstone, Mont., and vicinity	18	5:55–6:40 p. m.	[1] 1–8		5,000	do	Crop loss, $1,500; property damage, $3,500; path 8 miles long.
Saugus, Mont., vicinity of	18–19					Flood	Complete report under floods appears elsewhere in this issue of the Monthly Weather Review.
Federal, Wyo.	20	3:45–4 p. m.		0		Tornado	Windmill tower destroyed. This storm was observed generally from Cheyenne, Wyo.
Conner, Mont., vicinity of	21	Noon–1 p. m.	880		1,500	Hail	Loss to gardens, berries, and apples.
Carbon and Big Horn Counties, Mont.	21	3 p. m.			20,000	Heavy rain and hail.	Loss to crops by hail over an area 1 mile wide and 4 miles long, $15,000. Damage to property by flooding, $5,000.
Yakima, Wash., vicinity of	21				25,000	Thundersquall and hail.	Loss to fruit crop.
Cascade, Iowa, vicinity of	22	3–6 a. m.	[1] 4			Wind and rain	Fields flooded; considerable erosion; path 4 miles long.
Gallatin County, Mont., central and northern portions.	22	4 p. m.	[1] 1–3		25,000	Heavy hail	Loss to crops, livestock, and poultry; roofs and windows damaged. Crop loss, $20,000; other losses, $5,000.
Idaho County, Idaho, northwest portion.	22	5 p. m.	[1] 1		3,000	Hail	Property damaged; considerable loss to crops in some places; path 3 miles long.
Havre, Mont., vicinity of	22	6 p. m.	[1] 1–5		7,900	do	Crop loss, $7,200; property damaged, $700.
Hill and Blaine Counties, Mont.	22	6:22–6:50 p. m.		9	200,000	Excessive rain and flood.	Rainfall measured 1.78 inches at the Havre Weather Bureau Office. Visibility zero. Bull Hook Creek, the channel of which, runs through the city of Havre, rose to flood stage, suddenly and overflowed its banks, inundating most of the city with water from 2 to 3 feet deep. About 300 families affected in one way or another; the crest of the flood swept over the residential district and into the business section, flooding stores and warehouses. Many automobiles carried blocks away from their parking places. Water flowed through the Weather Bureau grounds filling the garage with 8 inches of water. Drainage water on the west slope of Bearpaw Mountains rushed through Gravelly Coulee with tremendous force. Small ranch houses and buildings demolished or carried off on the crest of the wave. Homestead washed out with a family of 6 and 3 men being drowned. About 440 yards of railroad track with ties washed out and carried about 100 yards.
Shawmut, Mont.	22	P. m.				Hail	Loss to crops, sheep, and poultry over a path several miles wide, reported to be several thousand dollars.
Springdale, Mont.[2]	22	do				Heavy rain	On the main line of the Northern Pacific R. R. a considerable portion of track washed out and a bridge below Springdale weakened by rushing waters. Highways under water for some time. The Cody, Wyo., highway, leading into Yellowstone National Park, near the park boundary, washed out.
Stillwater and Yellowstone Counties, Mont.	22	do	[1] 1–5		50,000	Hail	Loss to crops, $45,000; property damage, $5,000; path 60 miles long.
St. Johns, Ariz., 4 miles west	22				5,000	Heavy rain and flood.	Loss to crops; several cattle killed; highways damaged.
Miami, Fla., and vicinity	22				1,000	Thundresquall	High tension wire struck by lightning delaying electric service; a warehouse burned.
Pilot Rock, Oreg.	22	P. m.			200,000	Thunderstorm, heavy rain, and flood.	4 to 6 feet of water poured through this village of 300, flooding all stores and practically every house. Flood damage to buildings, bridges, merchandise, etc., estimated at $100,000. Loss to crops and cultivated lands in the canyon, $100,000.
Norfolk, Va.	23	1:45–2:55 p. m.				Thunderstorm and line-squall.	Streets flooded to depth of 3 feet in low-lying sections of the City; slight traffic delays; little dam age to shrubs and plants.
Presho, S. Dak., vicinity of	23	6 p. m.	[1] 5			Wind and rain	Tents in C. C. C. camp blown down; several barns destroyed; chickens killed and grain flattened.
Medford, Wis., vicinity of	23	7:30 p. m.				Electrical	Large barn containing 30 tons of hay and personal property destroyed.
Rapid City, S. Dak., and vicinity.	23	P. m.				Heavy rain	1 of the heaviest downpours for a short period on record at this station. Rainfall much heavier 20 miles east of Caputa where 2,600 feet of railroad track was washed out.
Parkston, S. Dak., vicinity of	24	2 p. m.		0		Tornado and rain	4 large barns wrecked; hogs, sheep, and chickens killed; fences and trees down.
Tripp, S. Dak., vicinity of	24	do	110	0	33,600	Tornado	1 person injured; farms buildings damaged; stock killed.
Centenary, S. C.	24	2:30 p. m.	[1] 1		32,158	Hail	Loss to crops; path 7 miles long.
Loris, S. C., and vicinity	24	2:40 p. m.			100,000	do	Much loss in tobacco and other crops, in some places a total loss; path 4 miles long.
Savannah, Ga., 3 miles west	24	3:55–4:05 p. m.				do	Automobile tops ruined; roofs damaged; leaves cut from growing crops.
Aiken and Orangeburg Counties, S. C.	24	5 p. m.	880		25,000	do	Loss to crops.
Springfield, S. C., vicinity of	24	do	880–1,760		6,500	Thunderstorm	Property damaged.
Nobles County, Minn.	24	6 p. m.			10,000	Hail	Heaviest losses in the vincinity of Reading, Minn. Loss to growing crops, $9,000; property damage, $1,000.
Do.	24	do	[1] 10		10,000	Thunder-squall	Heavy to excessive rains caused much damage from flooding. Barn, brooder house, and windmill demolished and several moved from their foundations or otherwise damaged. Much poultry perished; loss to growing crops; path about 75 miles long.

[1] Miles instead of yards.

[2] From press reports.

TABLE 4.—*Severe local storms, June 1938*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Joliet and Romeo, Ill., vicinity of.	24	6:10 p. m.	133		$1,000	Tornado	Near Joliet, several buildings and 2 box cars overturned. 8 miles northnortheast of Romeo, a tank car was blown from the tracks.
Carter, S. Dak., 5 miles north	24	7 p. m.				Wind, rain, and hail.	Loss to crops from hail; path narrow and 2 miles long.
Emmetsburg, Iowa, vicinity of	24	P. m.				Squall	Barn wrecked with 4 youths seriously injured and 3 cows killed.
Iowa, north-central portion	24	do			100,000	Wind and rain	No details.
Chaska, Minn.	24	do			10,500	Heavy rain and flood.	Stretch of railroad tracks washed out; basements flooded. A 90-foot, 11-ton retaining wall on the Carver County Courthouse grounds toppled over.
Fairmont, Minn., and vicinity	24	do			30,000	Rain and flood	Streets and basements flooded; damage to farm property, $24,500, included in the estimate given.
Fremont, Ohio, and vicinity	24	do				Thundersquall	Trees, poles, and wires down.
Suttons, S. C., vicinity of	24	do	[1] 2		15,000	Hail	Loss to crops; path 7 miles long.
Burdette and Wheaton, S. Dak.	24	do				Wind, rain and hail.	Loss to crops; barn wrecked; poultry killed.
Erwin, S. Dak.	24	do				High wind	Several windmills wrecked; chicken killed.
Frostburg, Md.	24				5,000	Electrical	Dwelling and garage burned.
Orient, S. Dak., vicinity of	24					Wind, rain and hail.	Several buildings wrecked.
Richie County, W. Va.	24					Torrential rain, electrical.	Inestimable damage to homes, barns, automobiles, garages, bridges, highways, railroads, and crops
Winneshiek County, Iowa	24–25	P. m.				Wind	A barn wrecked and several windmills blown down.
Idaho County, Idaho, northeastern portion.	25	6 a. m.	[1] 1		3,000	Hail	Much loss to crops over a small area; path 3 miles long.
Springfield, Ill., 4 miles south	25				6,000	Wind	Considerable damage to an airplane hangar, several planes, power lines and trees. Loss to crops.
St. Charles, Mo.	25					do	Wheat blown down; trees damaged.
Wayne, Green, Wilson, Pitt, and Nash Counties,[2] N. C.	25				500,000	Hail	Severe hailstorm; a number of growers reported their entire tobacco crop had been wiped out. Loss in cotton and corn included in the amount estimated.
Sedgwick, Kans.	25–26				9,500	Heavy rain and flood.	Property damage, $4,500; loss to crops, $5,000.
Phoneton, Ohio, vicinity of	26	3 p. m.	25	0		Tornado	At Patterson Field winds registered 60 miles-an-hour on a gust recorder. Damage to buildings, several thousands dollars. Small loss to wheat and other crops; path 3 miles long.
Glacier and Toole Counties, Mont.	26	5–8 p. m.	800–2,640		21,000	Heavy hail	Loss to crops.
Trenton, N. J.	26–27					Heavy rain	All records for 24-hour precipitation in June were broken, when for the 24-hours beginning 6:16 p. m., on the 26th, 4.79 inches of rain fell. A kiln wall, 50 feet long, weakened by the downpour, toppled by the wind. Streets and cellars flooded and in several instances, nearby highways were washed out and closed to traffic. At Trenton, the Delaware River rose nearly 5 feet.
Worthington, Minn., and vicinity.	29	P. m.			104,000	do	Property damaged.
Wisconsin, southeastern portion.	30					do	Much loss to crops; fields under water; grain beaten down. Washouts occurred on highways and railroads.

LATE REPORTS FOR MAY 1938

Buffalo, Okla., vicinity of	1	P. m.	[1] 1–3		$35,000	Hail	Much damage to wheat; slight damage to roofs of a few houses; path 17 miles long.
Altus, Okla., vicinity of	3	5:45 p. m.	67	0	4,120	Tornado	1 farmhouse completely destroyed; 2 persons injured; loss to crops, $120; property damage, $4,000.
Sharon, Okla.	3	P. m.	[1] 2		50,000	Hail	Loss to crops; path 12 miles long.
Bartlesville, Okla., and vicinity	6	4:10–4:30 p. m.	[1] ½–2		10,650	do	Crop loss, $10,000; property damage, $650; path 20 miles long.
Homing, Okla.	6	4:45 p. m.	[1] 4		10,000	do	Crop loss considerable, not estimated; path 5 miles long.
Purcell, Okla., 16 miles west	6	6 p. m.	[1] 2		6,800	do	Loss to crops, $6,000; property damage, $800; path 6 miles long.
Washita County, Okla.	6	6:30 p. m.	[1] 3–5		255,000	Wind and hail	In some places especially near Cloud Chief, hail drifted to a depth of 2 feet. Crop loss, $250,000; damage to roofs and other property, $5,000; path 20 miles long.
Garvin County, Okla.	6	7:20–8 p. m.	[1] 12		140,000	Heavy hail and wind.	Crop loss, $100,000; property damage, $40,000; path 24 miles long.
Pontotoc County, Okla.	6	8 p. m.	[1] 15		80,000	Wind and hail	Crop loss, $50,000; property damage, $30,000; path 20 miles long.
Holdenville, Okla.	6	8:30 p. m.	[1] 2–4		35,000	do	Crop loss, $30,000; property damage, $5,000; path 12 miles long.
Wilburton, Okla.	6	11 p. m.	[1] 4		3,000	do	Crop loss, $1,000; property damage, $2,000; path 10 miles long.
Stigler, Okla.	7	12:30 a. m.	[1] 2		9,855	Hail	Loss principally to crops; path 10 miles long.
Woods County, Okla.	18	7:20–8 p. m.	[1] ½–5		3,800	Tornadic wind and hail.	Property damaged; path 10 miles long.
Dewey and Wann, Okla., vicinities of.	19	6 a. m.	17		1,000	Tornado	Several buildings damaged.
McCurtain and Le Flore Counties, Okla.	22	7:30–8 p. m.	[1] 1		1,000	Wind	Several buildings damaged; many trees uprooted; path 25 miles long.
Tuskahoma and Albion, Okla.	22	9–9:30 p. m.	880		10,000	do	Many houses and barns unroofed, several porches torn away and garages blown down; path 12 miles long.
Carnegie, Okla.	26	3:30 p. m.	[1] 2		75,000	Hail	Crop loss, $70,000; property damage, $5,000; path 20 miles long.
Holdenville, Okla.	26	3:38–4:25 p. m.	[1] 3		10,000	do	Loss to crops and gardens, $5,000; other damage, $5,000; path 6 miles long.
Shamrock, Okla.	26	5:30 p. m.	[1] 1		1,500	do	Damage principally to roofs; path 5 miles long.
Coleridge, Nebr.	26	7:30 p. m.	[1] ½–2		10,000	do	Loss in small grains; damage to roofs.
Coalgate, Okla.	26	11:30 p. m.	[1] 1		3,500	do	Crop loss, $2,000; property damage; $1,000; path 12 miles long.
Carnegie, Okla.	27	5:30 p. m.	[1] 4½		125,000	do	Loss to crops, $100,000; property damage, $25,000; path 16 miles long.
Hockerville, Okla.	29	1–2 a. m.	[1] 4		5,000	do	Property damaged; path 8 miles long.
Quapaw, Okla.	29	3 a. m.			1,000	Tornado	Path narrow and short; no details.
Bartlesville, Okla., and vicinity.	31	5 p. m.	27		900	Wind	At the airport, wind of 54 miles per hour was recorded. Barn blown down; no crop loss.

[1] Miles instead of yards.

[2] From press reports.

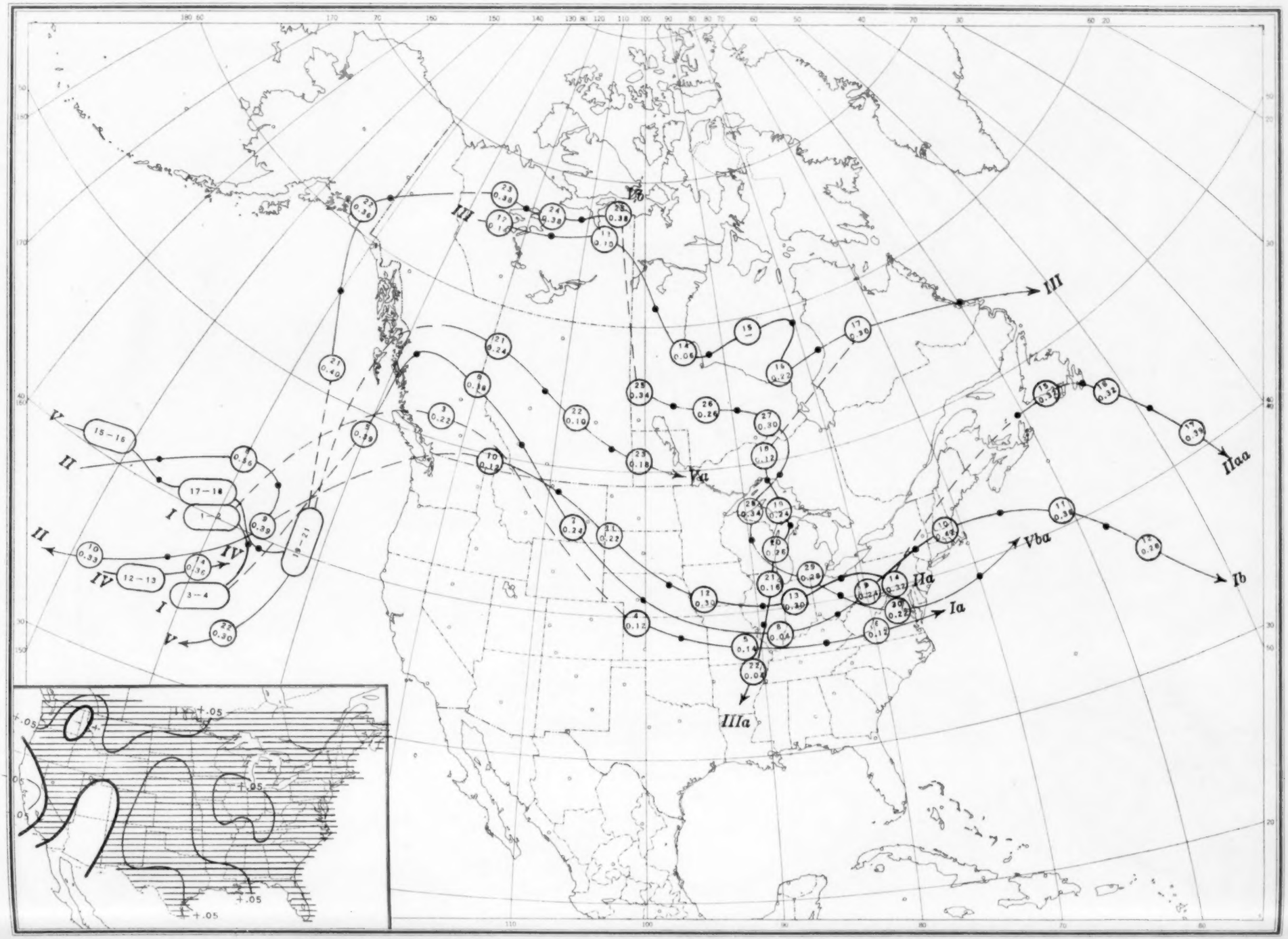
Chart I. Departure (°F.) of the Mean Temperature from the Normal, June 1938

Chart I. Departure (°F.) of the Mean Temperature from the Normal, June 1938

Shaded portions show excess (+)
Unshaded portions show deficiency (−)
Lines show amount of excess or deficiency
Statute Miles
Kilometers

Chart II. Tracks of Centers of Anticyclones, June 1938. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. P. Day)



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

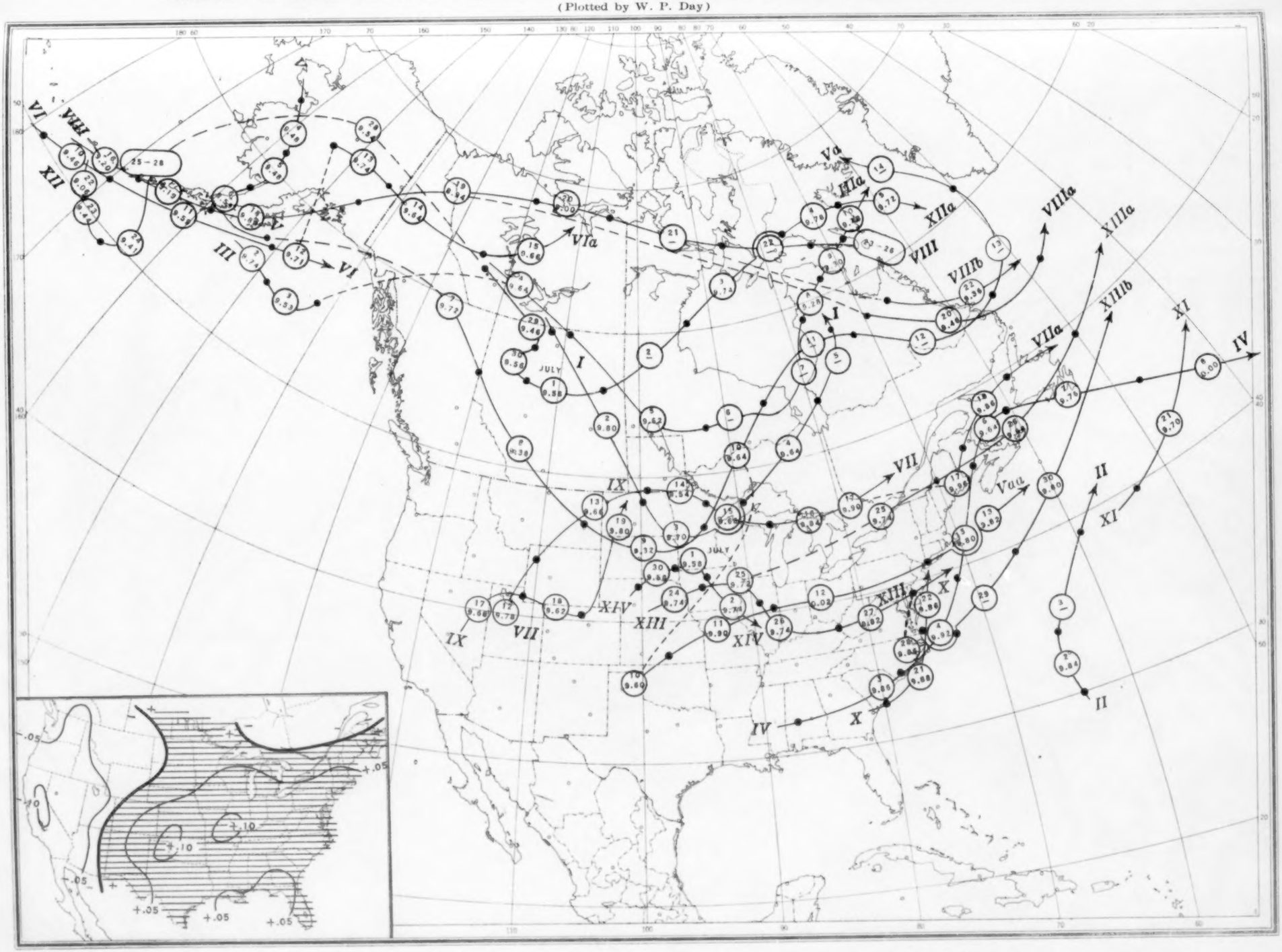
Chart III. Tracks of Centers of Cyclones, June 1938. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)

Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, June 1938. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by W. P. Day)



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, June 1938

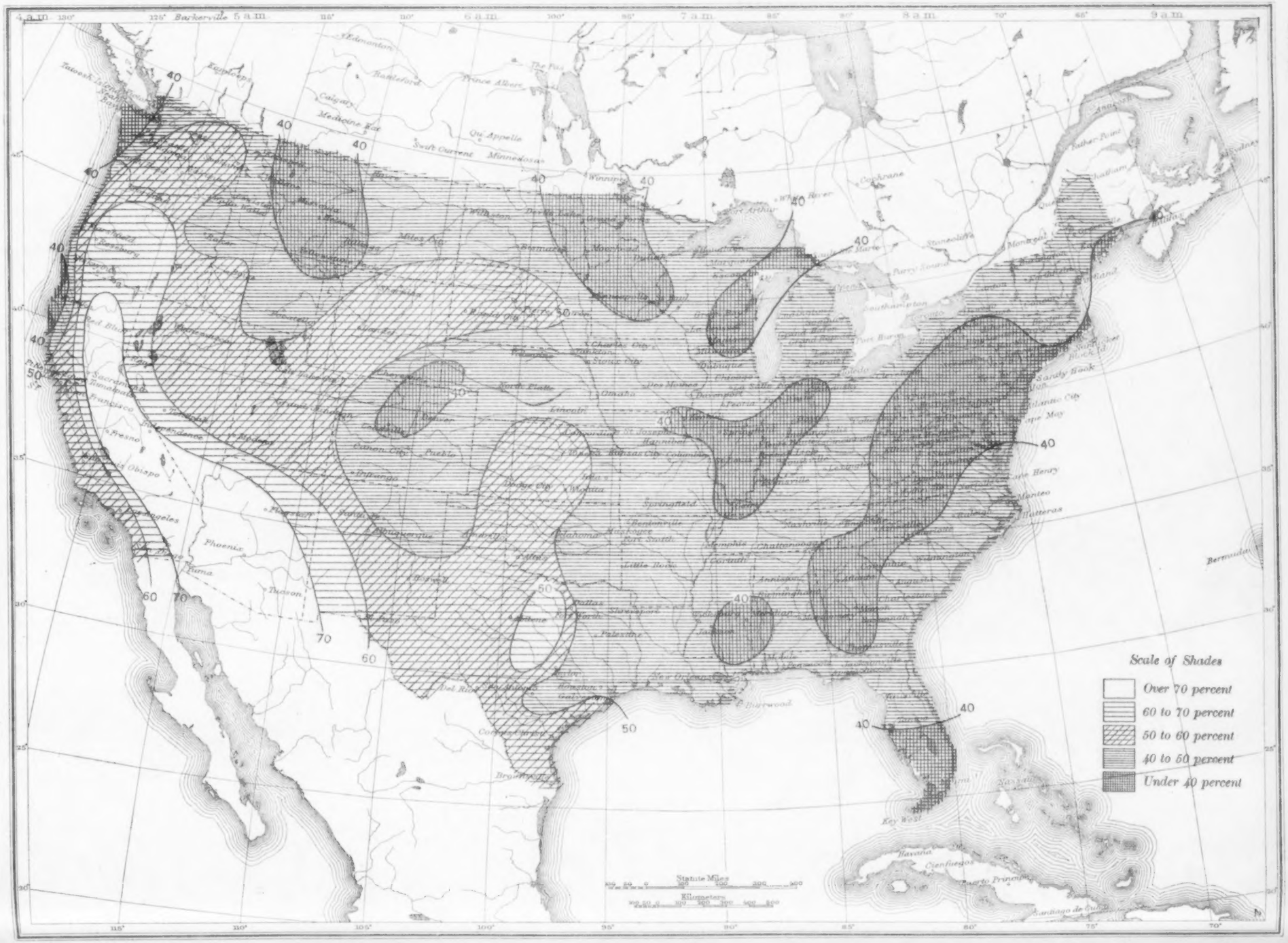


Chart V. Total Precipitation, Inches, June 1938. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, June 1938. (Inset) Departure of Precipitation from Normal

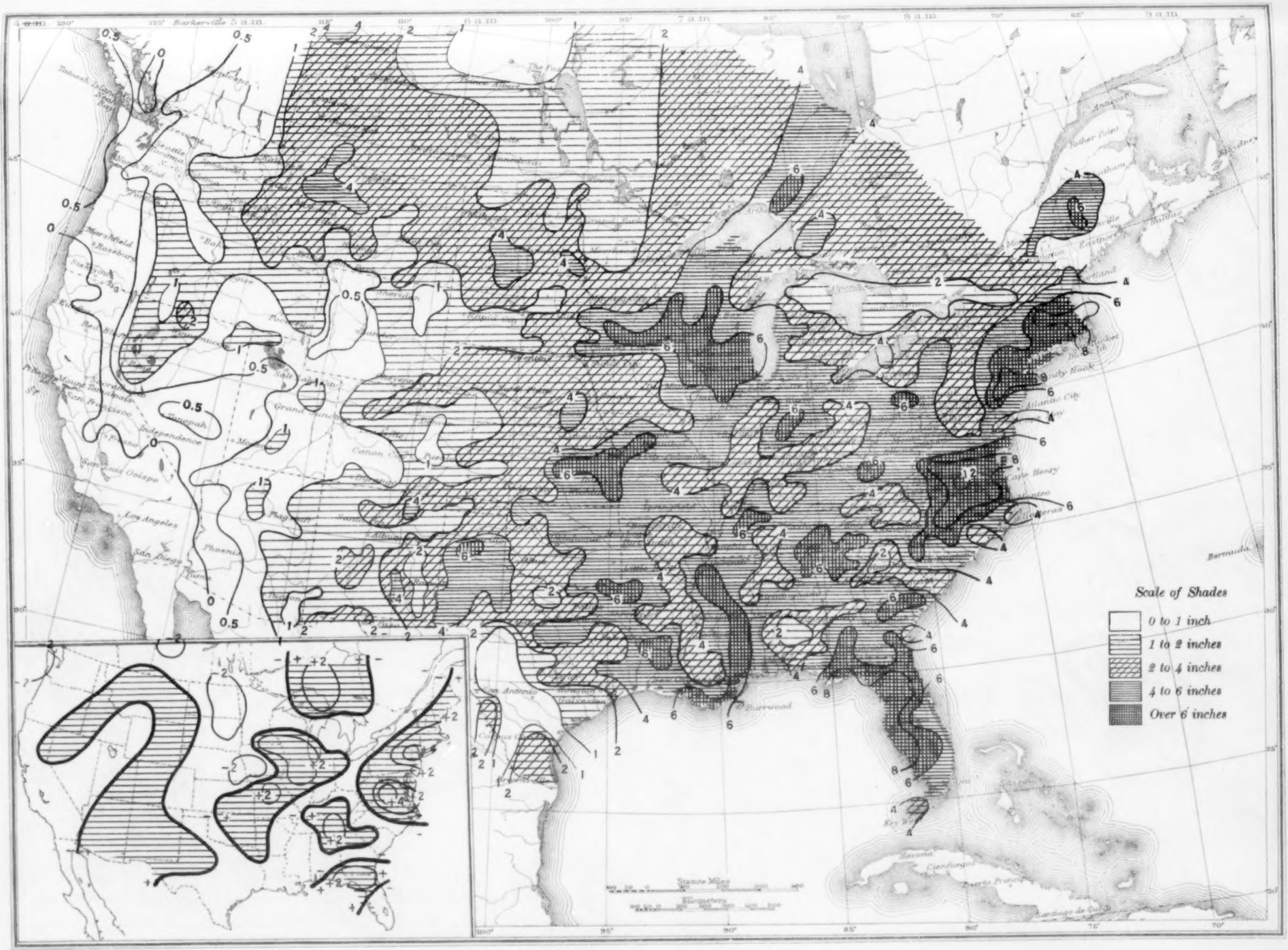


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, June 1938

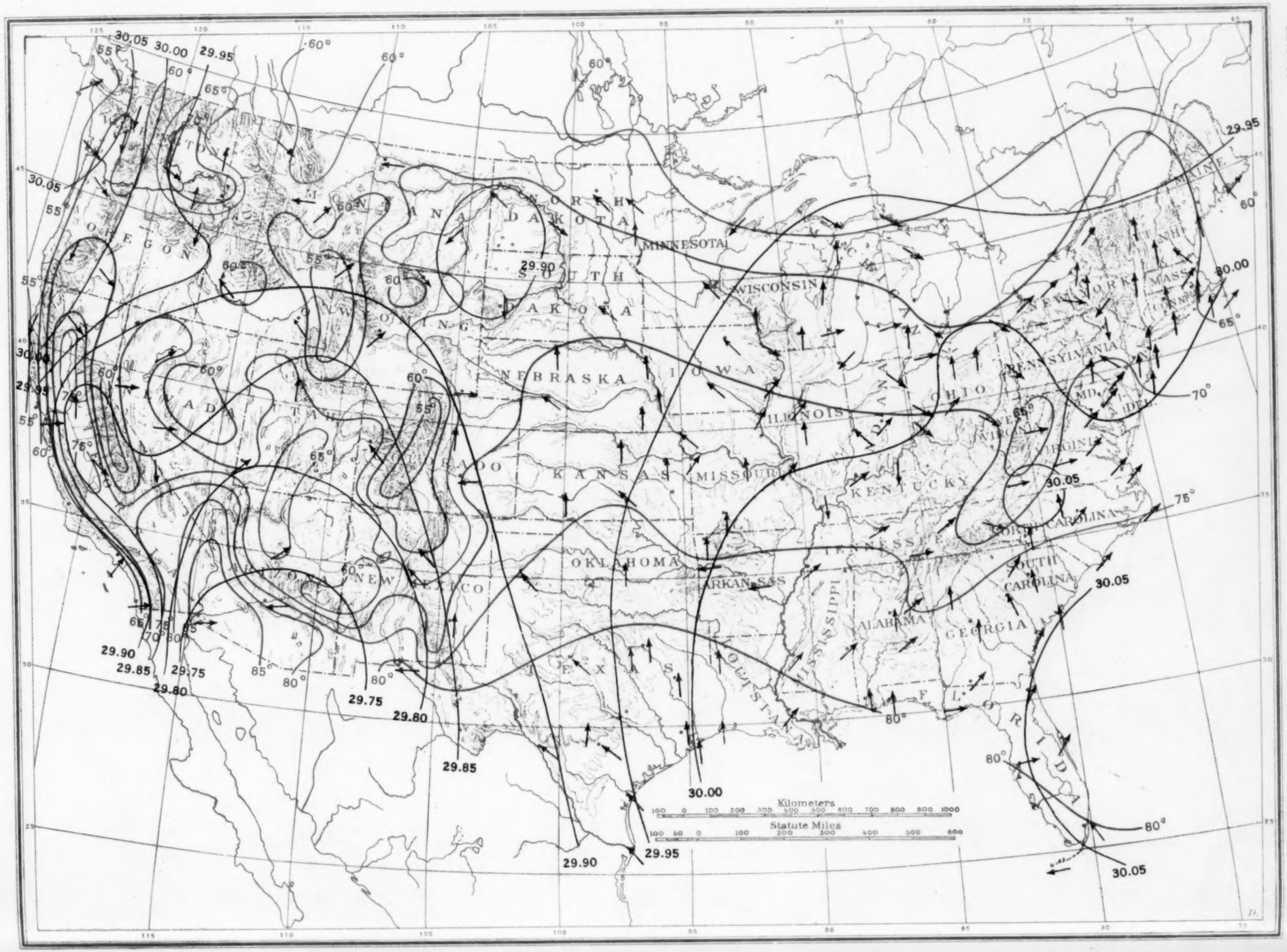


Chart VII. Wind Roses for Selected Stations, June 1938

(Plotted by W. W. Reed)

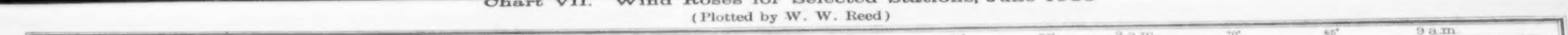


Chart VII. Wind Roses for Selected Stations, June 1938

(Plotted by W. W. Reed)

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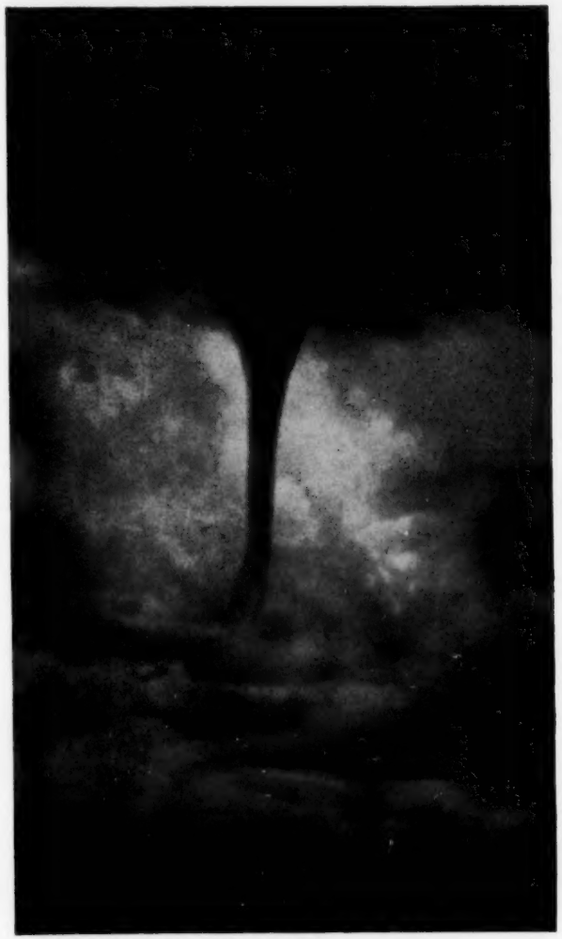

Photographs by Wright and Gale, York, Nebr.

FIGURE 1.—Formation of the tornado. The funnel cloud is descending earthward.

FIGURE 2.—The funnel cloud touching the ground. Note the attendant dust cloud.

FIGURE 3.—The funnel cloud with the appearance of a rising phenomenon due to the dissolution of its lower section; the dust whirl is still existent.